DOCUMENT RESUME

ED 199 114 SE 034 682

AUTHOR	Simonis, Doris G.
TITLE	Iowa Developed Energy Activity Sampler (IDEAS), Grades 7-12: Science.
INSTITUTION	Iowa Energy Policy Council, Des Moines.; Iowa State Dept. of Public Instruction, Des Moines.
PUB DATE	80
NOTE	313p.: For related documents, see SE 034 677-683. Pages 328, 377-380, 429-432, 468, 474, 485 removed due to copyright restrictions. Pages 19-172 contain the introduction which is the same for all modules. They have been removed and made into a separate document - SE 034 677.
EDRS PRICE	MF01/PC13 Plus Postage.
DESCRIPTORS	*Energy: Energy Conservation: *Environmental Education: Fused Curriculum: Futures (of Society): Physics: *Science Education: *Science Instruction: *Secondary Education: *Secondary School Science: Technology

ABSTRACT

Presented is the Science component of the Iowa Developed Energy Activity Sampler (IDEAS), a multidisciplinary energy education program designed for infusion into the curriculum of grades 7-12. Also contained in the program are activity sets for Home Economics (SE 034 678), Industrial Arts (SE 034 679), Language Arts (SE 034 680), Mathematics (SE 034 681), and Social Studies (SE 034 683). Contained in this manual are the 55 student-centered activities from the complete IDEAS curriculum that relate to secondary science. Topics of the lesson include energy flow, thermodynamics, energy limits, alternative energy sources, life styles, and insulation. Activities are arranged under six concepts: (1) Energy is basic: (2) Energy usefulness is limited: (3) The environment is affected by energy exchanges; (4) Energy choices affect society; (5) Conservation; and (6) The future is ours to shape and share. Lesson plans include discussion questions and background information, and they are usually illustrated with charts, diagrams, or drawings. (Author/WB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED199111

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Doris G. Simonis

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

I. D. E. A. S.

for

Science

SE 034 682

Iowa Developed Energy Activity Sampler

Sponsored by:
Iowa Energy Policy Council
in cooperation with
Iowa Department of Public Instruction

1980

Iowa Developed
Energy Activity Sampler
Grades 7-12

1980

Writer/Editor: Doris G. Simonis
The University of Iowa, Iowa City
Principal Illustrator: Charles D. Trapkus

This notebook is one of a series of six notebooks which include the subject matter areas of home economics, industrial arts, language arts, mathematics, science, and social sciences.

Many people contributed to the development of this project. The writer especially appreciates the support, suggestions, and enthusiasm of the following members of the Iowa Energy Education Advisory Committee:

Mr. W. D. Ackerman, Hoover High, Des Moines

Mr. Robert Anthony, Grant Wood AEA, Cedar Rapids

Sr. Margaret F. Brockamp, Kuemper High, Carroll

Dr. Jack Gerlovich, Department of Public Instruction, Des Moines

Dr. W. Tony Heiting, Iowa Energy Policy Council, Des Moines

Mr. Ted Pfeiff, Wallace Wood Jr. High, Davenport

Mrs. E. Verle Weiss, Denison High, Denison

The writer also wishes to extend thanks to the many creative people who provided specific information, poems, articles, or activities included in this publication. Their contributions are acknowledged individually where they appear.

This material has been produced under contract with the Iowa Energy Policy Council with federal funds disbursed under Public Laws 94-163 and 94-385.

Education and Energy

Background:

We live in a sea of energy, a balance of delicate and powerful forces that are so much a part of daily experience that their rhythm is often ignored. Life itself is energy conversion--intimate, dynamic, natural, precious, and taken-for-granted. Energy? We live it, use it, give it, and are suddenly surprised to discover that it is related to

—high prices;
—short supplies of basic goods and services;
—lack of national self-sufficiency;
--industrial, technological, educational systems;
—time and materials use;
—mobility, lifestyles, environmental problems, future options;
—quantity and quality of life.

Definition of the Problem:

Modern industry, agriculture, and transportation systems make possible a standard of living that is dependent upon cheap, easily transportable energy sources. Use of inherited energy capital (fossil fuels) for expanded industrial and agricultural production has supported a population that is now far larger than that which existed throughout the world's previous history, and the population is still growing. Moreover, individuals are using increasing amounts of fossil fuels as they acquire more manufactured articles and adopt energy-intensive lifestyles.

Strategy:

The framework used in developing the following activities is the "infusion" model. Recognizing that various aspects of energy education fit well into existing disciplines—especially (but not exclusively) the sciences, social sciences, home economics, mathematics, industrial arts, and language arts--the Iowa Energy Policy Council and the Energy Education Advisory Committee hope that individual teachers will choose activities that complement and extend the topics usually covered or the skills to be developed and strengthened in their classes.

Some suggestions may stimulate cooperative multidisciplinary or interdisciplinary activities as well. Energy education is interdisciplinary because every area of human endeavor depends on energy. The emphasis on energy as a basic consideration for every aspect of life will put a new perspective on much human knowledge and show a "connectedness" that was not obvious before. Energy choices are not only technological ones; they are likely to have multivariate effects on personal and international economics, the environment, and its capacity to safely sustain us, the materials our children may hope to use, and the lifestyle options that future generations may have.

A variety of approaches is recommended for teaching about energy. The activities included are just a few examples of the ways to stimulate an energy awareness, new perspectives on the interdependencies of people and other living things, and recognition of human value/choice/action synergies that will shape the future. Teachers and students can demonstrate, experiment, build, discuss, debate, survey, role-play, write, draw, research, explore, brainstorm, consider alternatives and consequences, model, investigate, measure, calculate, dramatize, and display progress in understanding energy and in practicing less wasteful energy use.

Energy flows in all directions throughout the physical world, but some of it comes to a focus in the biosphere and in the flowering of human culture. It seems natural that energy awareness should also grow by a gathering of illuminations from various sources, both practical and theoretical, and should involve many skills. Ideally, energy education will foster curricular integration, will help develop a conservation ethic, and will challenge the inventiveness and initiative of creative minds.

Summary of Energy Education Concepts

1. Energy is basic.

   Energy exists in various forms and states.
   Energy flows, transfers itself.
   Life itself is energy conversion, a series of interactions with the physical world.
   Humankind measures energy in various ways.

2. Energy usefulness is limited.

   Laws of thermodynnamics describe physical constraints.
   Natural resources are limited in amount and in usefulness. They require energy to extract, so "net yield" accounting is necessary for future developments.
   Exponential rate of using cannot continue.
   Economics dictate some restrictions.

3. Environment is affected by energy exchanges.

   Mined (fossil) energy measurably disrupts natural systems during
   - a. extraction
   - b. transportation and distribution
   - c. consumption (including electrical generation).

   Capturing solar and wind energies may require new materials, non-traditional land allocations, and population shifts with unknown side-effects on global environment.
   All other energy alternatives also will cause varying degrees of environmental change.

4. Energy choices affect society.

   Energy is the true basis of economics.
   Lifestyles vary with energy use.
   Employment patterns vary with energy availability.
   Life, health, and literacy have been correlated to energy consumption.
   International relations and trade are directly influenced by energy distribution.
   World inequities in energy supplies suggest future challenges and priorities.

7

5. The case for conservation.

There is a need to conserve and "buy time" for a more gradual energy transition and development of alternatives.

The relative importance of energy-using activities must be considered:

- a. actual needs
- b. perceived needs
- c. non-essential uses

Ways to reduce energy consumption must be explained and demonstrated.

6. The future is ours to shape and share.

Time-sense must be developed, the present in relation to past and to projections for the future:

- a. mid-term of "one generation" or ∽ 30 years.
- b. long-term alternatives and possibilities.

Dreams for the future are the only realizable ones. Without them we act blindly.

"Quality of life" may be redefined.

Teaching the Energy Lesson

The activities included in this publication are not a special step-by-step "course." Rather, they are suggestions to get interested teachers started on the process of incorporating energy concepts into existing classes.

The concepts represented by particular articles and activities include those outlined under Summary of Energy Education Concepts. Briefly, they are that:

1. Energy is basic.
2. Energy usefulness is limited.
3. Environment is affected by energy exchanges.
4. Energy choice affects society.
5. Conservation is essential.
6. The future is shaped by today's decisions.

Some of the activities are teacher-directed or demonstrated. Others are student-centered, chances to handle materials or information and to observe events that might otherwise go unnoticed. This second category of activities is the more important for intellectual maturation of the student.

Too many students have never observed a ball repeatedly rise and fall, nor seen fresh bread dough expand. They don't know which way the wind blows. They've never taken apart a battery, a camera, or a gear system. They've never considered other lifestyles either, nor the social and environmental effects of exponential increases in energy use. They should get their hands and minds exposed to human variables as well as physical ones. After students handle materials and manipulate viewpoints, they may be ready for more formal analyses and (hopefully) will come to see social and environmental dynamics with new insights.

The limited research done so far on teaching energy conservation and need to change patterns of energy use suggests that practical experience is necessary. Measuring energy use at home and school, installing insulation or making a solar collector, experimenting with small changes in lifestyle, and exchanging viewpoints with others whose hobbies, habits, and career choices may be or have been affected by energy futures seem to be effective means of encouraging young people to make energy-use changes in their own lives.

Science and technology are important in outlining limits to energy alternatives, safety, storage, and environmental insults. However, national proposals that call for major commitments to the development of more and more energy (delaying transition) draw attention away from the more significant social issues of energy distribution inequities, economic pressures, political repercussions, and international tensions. There are complex synergies whose existence are just becoming recognized, but are so much a part of the changing patterns of human life that they cannot be ignored. Therefore, this group of activities includes some that are related more to social studies and aesthetics than to pragmatic devices for measuring energy flows. This mix should emphasize the interdisciplinary and transdisciplinary nature of ENERGY to individual teachers.

Some of the articles prepared for this handbook are intended primarily for the teacher's information and background. If you want to introduce these topics to your students, adapt them any way you like.

Other articles "fit" more into one discipline than into another. Several are multidisciplinary, much depending on the emphases chosen by the teacher. Still others may involve other teachers, members of the community, families, or the school custodian. The summary and recommendations following are only suggestions, not limits. They may save time in making initial choices of activities to use in your classroom.

But don't stop there!

Energy Education:
General Objectives for Teachers

Successful energy education will encourage teachers:

1. To become knowledgeable about energy sources, uses, and conversions.
2. To recognize physical limits to energy availability and usefulness.
3. To recognize bases of human dependence on natural energy resources and the world-wide diversity of social responses to that relationship.
4. To become knowledgeable about environmental effects of energy exchanges and to recognize cost/benefit relationships and conflicts of values that need to be considered.
5. To know the "why" and "how" of energy conservation and to apply that knowledge.
6. To develop a forward-looking perspective; to broaden awareness of social, technological, and natural resource options; and to recognize the urgency of the need for planning.
7. To involve students in activities that help develop:
    a. their knowledge of energy relationships;
    b. their willingness to conserve and to make more productive use of resources;
    c. their awareness of value-bases for choices; and
    d. their talents for decision-making, planning, designing, and innovating that will affect the future.

Energy Education:
General Objectives for Students

Energy education will enable students:

1. To know more about energy sources, uses, conversions, and limitations.
2. To become aware of diverse, world-wide human responses to available energy resources.
3. To recognize that the environment is affected by energy exchanges, and that all energy use has costs as well as benefits for human society and its physical support system.
4. To develop a conservation ethic strong enough to be expressed in effective personal actions.
5. To acquire a sense of historical perspective that relates the present both to the past and to the future.
6. To develop decision-making skills and the confidence that personal and community choices and activities can affect the future in positive ways.

12

Key to Energy Activity Inventory

Type of Activity:

BI = background information for the teacher. All energy-educators should have this introduction, regardless of grade level or subject area.

TD = teacher-directed activities, like demonstrations or class discussions needing a moderator.

SC = student-centered activities, "hands-on" building or data-collecting experiences that can be done individually or in small teams. These often have directions and worksheets to be duplicated for student use. Teacher's notes usually supplement the student information, include hints on classroom management.

Subject Matter Areas:

⌂ **HE** = home economics

⊛ **M** = mathematics

⚙ **IA** = industrial arts

⚗ **S** = science

🗣 **LA** = language arts

🌐 **SS** = social sciences

Energy Activity Inventory

Concept: Energy is Basic

It exists in various forms and states that can be measured and appreciated in various ways. It flows and transfers itself. Life itself is energy conversion, a series of interactions with the physical world.

Title	Type	Subjects	Grades	Page
CALORIES, CALORIES	SC	HE, IA, S	9-12	173
CANNED SUNSHINE	SC	HE, IA, S	7-12	177
COLOR IT HOT	TD	IA, S	7-12	185
ENERGY AND LANGUAGE ARTS	TD	LA, SS	7-12	
ENERGY AND LIFE	BI			19
ENERGY WORD GAMES	TD	HE, LA, S	7-9	187
GETTING FACTS ON ENERGY USE	BI			21
GO WITH THE FLOW	SC	IA, S	7-9	191
HEAT CAPACITY AND TEMPERATURE	BI			22
HIGH COST OF LIVING - I STUDY OF A HERBIVORE	SC	S	9-12	197
HIGH COST OF LIVING - II STUDY OF AN AUTOTROPH	SC	S	9-12	203
MEASURING ENERGY	TD	HE, IA, M, S	9-12	209
NEWS AND NOTES ON AGRICULTURE	BI			23
NEW/OLD IDEAS ON COOLING BY EVAPORATION	BI			25

Energy Activity Inventory

Concept: Energy is Basic

Title	Type	Subjects	Grades	Page
NOTES ON GRAPHS AND CHARTS	BI			27
PLANTS AND LIGHT ENERGY - I	TD	S	7-10	215
PLANTS AND LIGHT ENERGY - II	SC	S	10-12	217
POPSICLE POWER	TD,SC	S	7-12	221
POTENTIAL ENERGY IN SUGAR	TD	S	10-11	225
POWER PUFFS	SC	HE, IA, S	9-12	227
RENEWABLE VS. NON-RENEWABLE ENERGY	TD	IA, M, S	7-12	229
SOLAR CLINOMETER	TD	IA, S	9-12	233
SPOTTY POWERPLANT	SC	M, S	9-12	235
SUN FUN	TD	HE, IA, S	7-9	241
SUN'S POSITION IN THE SKY	SC	IA, S	9-12	243
UP WITH PEOPLE POWER	SC	IA, M, S	9-12	253
WAXING HOT	TD,SC	IA, S	7-12	257
WORDS ABOUT ENERGY - I	SC	HE, S	9-12	259
WORDS ABOUT ENERGY - II	SC	HE, LA, S, SS	9-12	265

Energy Activity Inventory

Concept: Energy Usefulness is Limited

Laws of thermodynamics describe physical constraints. Natural resources are limited in amount and usefulness. They require energy to extract. Exponential growth cannot continue indefinitely.

Title	Type	Subjects	Grades	Page
ELECTRICITY AND NATURAL RESOURCES	TD	SS	9-12	
ENERGY AND LIMITS	BI			37
ENERGY AND EFFICIENCY	BI			41
ENERGY RESOURCES	BI			49
ENERGY RESOURCE SUMMARIES	BI			53
FUEL SUPPLY AND DEMAND	TD	M, S	9-12	269
GROWING TIME (Exponential Growth)	BI			67
LIGHT FANTASTIC, THE	BI			79
MODELING EXPONENTIAL GROWTH	SC	M, S, SS	10-12	271
PLANET EARTH: SOME MEASURED LIMITS	TD	M, S	10-12	281
SQUARING "ON THE DOUBLE"	TD	HE, M, S, SS	7-10	289
SUPER-TANKER EARTH	BI			81
THERMODYNAMICS: SOME BASIC ENERGY LIMITS	TD	HE, IA, S	7-12	293

Energy Activity Inventory

Concept: The Environment is Affected by Energy Exchanges

Mined fuel disrupts natural cycles. Alternatives must be developed but they will also have varying degrees of social, cultural, economic, and environmental effects.

Title	Type	Subjects	Grades	Page
BLOWING IN SOME CENTS	SC	HE, IA, M, S, SS	8-12	303
ENERGY AND HOME SITE DEVELOPMENT	TD	HE, IA	7-12	
ENERGY DEBATE, THE	SC	LA, S, SS	8-12	307
ENERGY AND POETRY	TD	LA, S	9-12	319
GREENHOUSE EFFECT, THE	SC	IA, S	7-12	329
HUMDRUM OR HOME DOME?	TD	HE, IA	7-10	
INVESTIGATING PASSIVE SOLAR HOME HEATING	TD	HE, IA	7-12	
MINI DRUM-WALL	TD, SC	HE, IA, S	7-12	335
NUCLEAR FUSION	BI			85
SIMPLE SOLAR OVEN	SC	HE, IA, S	7-12	343
SOLARIMETER, LET'S MAKE A	SC	IA, S	9-12	349
SOLAR STILL, A	SC	IA, S	7-9	355
WINDMILL, A CLASSROOM SAVONIUS	TD	IA, S	9-12	359
WIND POWER	BI			89

Energy Activity Inventory

Concept: Energy Choices Affect Society

Lifestyles, employment, economics, quality of life, international relations, attitudes and choices are among elements directly related to energy use.

Title	Type	Subjects	Grades	Page
ENERGY AND STANDARD OF LIVING	TD	HE, S, SS	7-9	363
ENERGY AND TRANSPORTATION	SC	HE, LA, SS	9-12	
ENERGY IN MANUFACTURING - I	SC	HE, SS	7-12	
ENERGY IN MANUFACTURING - II	TD	HE, IA, M, SS	9-12	
ENERGY OPINIONS AND PRIORITIES	SC	LA, M, SS	7-12	
HOW MANY HIDDEN HELPERS	BI			91
HOW NOW, DRY COW	SC	HE, M, SS	7-10	
INTERDISCIPLINARY APPROACH	BI			96
LIFE STYLES AND ENERGY USE - I	TD	HE, SS	7-12	
LIFE STYLES AND ENERGY USE - II	SC	HE, LA, SS	9-12	
LIFE WITHOUT ELECTRICITY: A PEACE CORPS EXPERIENCE	TD	HE, M, S, SS	7-10	365
MAN, ENERGY, AND ENVIRONMENT: SOME ATTITUDES AND BELIEFS	TD	LA, S, SS	10-12	371
NEWS WARM-UP	TD	LA, SS	7-12	
OIL EMBARGO AUCTION	TD	HE, SS	7-9	
OIL, TRADE DEFICITS, AND THE 51ST STATE	TD	SS	8-12	
SOME ENERGETIC FIGURING	SC	M	8-10	
TRANSPORTATION FACTS	BI			99

Energy Activity Inventory

Concept: Conservation

Conservation means more productive use of necessary energy supplies and elimination of non-essential consumption. Careful use of fossil fuels can "buy time" for a more gradual energy transition.

Title	Type	Subjects	Grades	Page
BAKER'S DOZEN, THE	SC	HE, LA, S	7-9	381
CABIN FEVER I SURFACE AREA	SC	HE, IA, M, S	8-12	383
CABIN FEVER II INSULATION	TD	HE, IA, M, S	7-12	391
CABIN FEVER III INFILTRATION	TD	HE, IA, S	7-12	397
CABIN FEVER IV SITE AND PLANTINGS	TD	HE, S	9-12	401
CABIN FEVER V HUMAN FACTORS	TD	HE, SS	9-12	
CHECKING WALL INSULATION	SC	HE, IA, S	7-9	409
CONVENIENCE AND ENERGY	TD	HE, M	7-12	
ELECTRICITY FOR FUN, CONVENIENCE, WORK	SC	HE, SS	7-9	
ENERGY AND AGRICULTURE	BI			100
ENERGY: WASTE AND PRODUCTIVITY	BI			103
FOOD-ENERGY CONSERVATION	SC	HE, S	10-12	411
HOMES AND SCHOOLS' ENERGY EFFICIENCY	TD	HE, IA, M, S	9-12	415
ON THE ROAD TO ENERGY SAVINGS	SC	HE, IA, M	9-12	
READING ELECTRIC METERS	SC	HE, IA, S, SS	7-12	417
TRANSPORTATION: CARPOOLING SAVES	TD	HE, M, SS	7-12	
WATERBAGS	TD	LA, S, SS	7-12	429
WINDOW COVER PROJECT	SC	HE, IA, S	7-9	435

Energy Activity Inventory

Concept: The Future is Ours to Shape and Share

Time-sense must be developed, the present in relation to the past and to decisions affecting the future. "Quality of life" may be redefined.

Title	Type	Subjects	Grades	Page
ENERGY CONVERTERS AND POWER	TD	M, S, SS	10-12	441
ENERGY AND THE QUALITY OF LIFE	BI			106
ENERGY TRANSITION AND CHALLENGE	BI			113
ENERGY USE AND DECISION-MAKING	TD	HE, S, SS	8-12	451
HISTORICAL DIGEST	SC	M, S, SS	9-12	457
TRENDS AND CONSEQUENCES: The Futures Wheel	TD	HE, S, SS	9-12	465
YE OLDE TIMES, SUN PRESS, and STAR GAZETTE	TD	HE, LA, S, SS	7-12	469

PAGES 19-172 CONTAIN THE INTRODUCTION. THEY HAVE BEEN REMOVED AND MADE INTO A SEPARATE DOCUMENT — SE 034 677.

Calories,Calories, Who's Got the Calories

Objective:

To measure the relative heat content of some common materials; to become familiar with some energy-related terms: fuel, calories, heat transfer, heat loss.

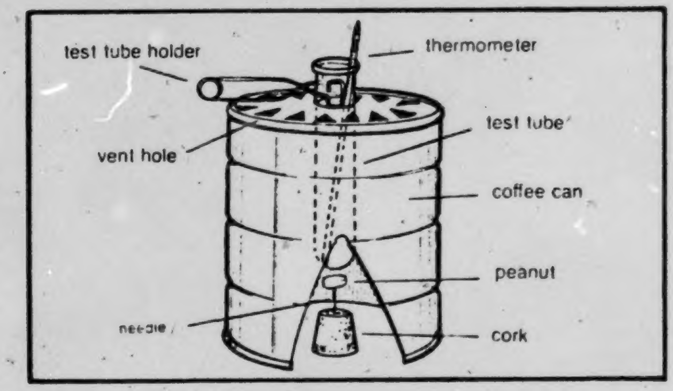
Materials:

Coffee can, metal punch, tin snips
Test tube and holder
Cork
Needle
Shelled peanuts, wood chip, sugar cube,* charcoal, coal, peat, praffin, paper wad, dried bread cube
Wooden kitchen matches

Procedure:

1. Set up the coffee can and other items as shown.

2. Put 60 ml of H_2O into a test tube. Record the water temperature. Then take the thermometer out of the test tube.



3. Decide which material you will test first. Weigh a small amount of it (0.2 to 0.3 grams). Don't use more than this. If you cause the water to boil off before the too-big sample burns completely, you won't have a way to know how much heat was transferred.

**The sugar cube will burn more easily if rolled in cigarette ashes first. Or use a clean cube and put it in position under the test tube. Then carefully, using an eye dropper, put two-to-three drops of concentrated sulfuric acid on the cube.*

4. Put the sample firmly on the needle which is, in turn, secured in the cork.

5. Use a match to start your sample burning. Then put the burning sample under the test tube as quickly as you can. Do not put your face over the top of the test tube and do not point it at anyone.

6. Watch the sample until it burns completely. When the flame goes out, take the temperature of the water in the test tube. Put this reading on your record sheet. Calculate the change in water temperature and the calories gained. One calorie is the heat required to raise the temperature of one ml of liquid water 1° C. You used 60 ml water, so you will multiply:

   $(°C_2 - °C_1) \times 60 =$ ____________________ calories

7. Repeat this procedure two or three times with the same fuel and compare results.

8. Choose another material, and weigh another small sample (0.2 - 0.3 g). Repeat the above procedure, recording water temperature before and after burning the fuel.

9. Complete your calculations on the record sheet. Compare results with classmates to determine which material transferred the most calories to the water.

Questions:

1. What was the most concentrated fuel tested by the class? (Look at the calories/g fuel.)

2. There are 1,000 gram-calories in one food Calorie or kilocalorie. Keeping this in mind, look up the number of Calories that bread, sugar, and peanuts are reported to have. How do your results compare?

3. What seemed to be the cleanest fuel you burned today? (Consider residue on the needle or on the test tube as "pollution.")

4. Why did you need to use a match to start the reation? Does it always take energy to get energy?

5. What is the reason for not trying to set fire to the sample while it is under the test tube?

6. Based on this experience, define "fuel".

Student Record Sheet

CALORIES,
CALORIES!

Name ____________________
Date ____________________

Fuel Type	Fuel Weight	°C_1 of H_2O (start)	°C_2 of H_2O (at end)	Change, °C (C_2-C_1)	Calories gain (change x 60)	Cal/gm. Fuel

Canned Sunshine

You can get some basic information about collecting solar energy by building and testing a simple passive collector. How hot will a sun-exposed can get? How can the Sun's radiant energy be captured for heating your living and working areas? What are the essential parts of a solar collector? These are some of the many questions you may want to ask and try to answer as you do the following activity.

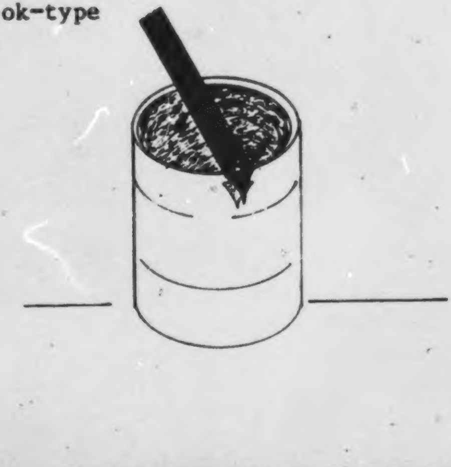
Materials:

One large can, about 12-14 cm diameter and 14-17 cm tall (a 3# coffee can or 2 1/2# vegetable fat can will do).
One smaller can, about 10 cm diameter and 1 cm or more shorter than the large can. (It must fit inside the larger can with room for a layer of insulation between the can bottoms and sides.)
Punch can opener
Standard laboratory thermometer (registering to 110° C)
Watch or clock with second hand
Plastic can lids, plastic wrap, waxed paper, colored cellophane, etc. as available
Duct tape
Rubber bands
Insulating materials: shredded paper, cotton, styrofoam, fiberglass, wood shavings, sawdust, cork, popcorn, as available
Paint and brushes or spray paint (flat black enamel)
Graph paper

Procedure:

1. Paint or spray the inside of the smaller can with black paint.

2. Punch one hole in the side of the small can, just big enough for the thermometer to slip through. (Position the hook-type can opener on the upper, open edge of the can. It will be easy to push in and all holes made will be the same distance from the top edge.)

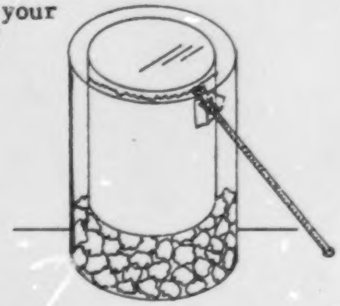


3. Punch a hole in the larger can the same way.

4. Choose one of the cover materials to stretch across the top of the small can. If necessary, secure it with a rubber band.

5. On the bottom of the larger can, put a layer of insulating material thick enough to raise the smaller can, when placed in it, so that its hole and that of the larger can line up.

6. Insert the thermometer bulb into the smaller can. Adjust the thermometer position so that you can easily read the mercury. Then close any irregular outside edges of your punched openings by taping small pieces of duct tape over any exposed areas.



7. Place your collecting cans in the sun and record the inside temperature each minute for 20 minutes. (If you have an outside table or a piece of board that everyone can use, tilt the surface until the cans' shadows are minimized. You will get best results when the Sun is hitting the can coverings as directly as possible. However, all cans should be positioned alike. In order to allow fair comparisons of your results using different materials, the collecting conditions must be the same.)

8. Have a classmate or the teacher record the air temperature of the surroundings while the collectors are "working".

9. Plot the data on a graph. Put temperature on the vertical axis and time on the horizontal axis. Use the background air temperature data also for a "base-line" comparison.

10. Cool down your cans and then put insulating material in all the space between the two cans.

11. Repeat procedures number 7 and number 8.

12. Compare results on the graph you already made. Connect the new data points with colored or dotted lines to distinguish them from the original ones.

13. Compare results with those of classmates who used different cover materials and/or different insulation.

Questions:

1. According to class results, which type of cover material appeared to be most effective? (Look for change in air temperature achieved as a measure of collector performance.)

2. Which type of insulation seemed to work best?

3. Why is it necessary to use insulation in a solar collector?

4. Of the materials that the class tested, which combination of glazing and insulation material would you recommend for a demonstration collector?

5. The collector you just used is like many used in solar-heated hot air systems. Can you identify the five basic components in a solar collector, using yours as a model?

6. If you were building a roof top collector for your home or school, what kinds of materials would you need?

Advanced Canning Research:

1. Put a lid on the outer can as well as on the inner one. Compare results with those from standard procedure.

2. Try different colors on the inner can surface. Is red or blue or green as effective as black? How does a shiny (unpainted) tin can perform?

3. Try painting the outer can as well. Does this affect collector performance?

4. Follow the procedure previously described with three different sizes of inner cans. A one-pound coffee can, no. 2 1/2 size fruit can, and 13 1/2 oz. tuna can, for example, all have the same diameter (about 10 cm) but different heights (approximately 13.8 cm, 11.7 cm, 5.7 cm respectively). Look for a relationship between temperature change, volume of air heated, and area of the glazed surface exposed to the Sun.

5. Must the cover admit light to be effective? Use a foil-covered can lid (shiny), a black-painted foil cover, and a black polyethylene cover as alternative "controls". Do they heat up as well as the clear-covered can? Do they cool as quickly? (Record cooling data every minute for 20 minutes with cans in the shade.)

6. Consider effects of wind, clouds, or extreme environmental air temperatures on a solar collector. Discuss ways to measure these effects.

7. Try tilting otherwise identical can collectors at various angles. Measure temperature changes as before. Do results suggest any improvements that would increase efficiency of a solar collector?

Teacher's Guide to Canned Sunshine

Basic information on solar collectors is provided on the next page. Use it for your information only or make copies for your class, as you choose.

This activity could be done with various-sized shoe boxes instead of cans. However, cans are sturdier and once painted and punched, the same ones may be used by several classes and/or reused on successive days without breaking down.

This procedure is based on the use of a standard household can-puncher. Warn students to avoid running fingers over the raw edges. A metal punch would make neater holes and eliminate need for the duct tape, if someone other than the students can prepare the cans ahead of time. Use a backing to prevent denting the can.

Collect cans or boxes well in advance of starting the activity. Be sure you have enough of the same sizes so that assemblies are comparable. Recommended are 1 lb. and 3 lb. coffee cans plus their plastic lids; 2 1/2-3 lb. vegetable fat cans with plastic lids; #2 1/2 size fruit cans (1 lb., 13 oz. net wt.) and large tuna fish cans (13 1/2 oz. net wt.).

The "advanced canning research" suggestion number 4 (for high school students) can best be done using the fruit, tuna, and 1 lb. coffee cans (all use the same size lid) for the inner can, thus keeping glazed area constant while varying the depth and volume of the can. Results can be expressed quantitatively and should suggest the advantage of a "flat plate" conductor over one that is deeper relative to sun-exposed surface.

Also, this advanced activity raises some interesting questions on heat vs. temperature. If all three collectors are receiving the same amount of sunlight (having the same kind and amount of surface exposed to the sun), why don't all three reach the same temperature at the same time? This is an opportunity to describe temperature as average heat of the surroundings, not total heat.

The basic activity will probably require three days total: one for construction of the collectors, one or two for data collection, and one for graphing and interpreting the results.

Divide the class into several groups, each of which is assigned different combinations of glazing and insulating materials. Be sure that each collects data under the same atmospheric conditions to eliminate differences in amount of sunlight available. Ideally, you will have an outside table or some large boards that everyone can use. Tilt the table or boards just enough that the can shadows are as small as possible, and no can is in a shadow. You will get best results when the sun is striking the collector covers as directly as possible.

Results will vary, depending on combination of insulation and glazing used and depending on the time of day and time of year. The greater the insulation and the better the insulation, the higher the temperatures expected. When air is the fluid conductor, a second layer of glazing (on the outer can) with air space between it and the inner can will usually increase the temperature rise.

Evaluate students on ability to follow instructions and to work with others; on organization and analysis of the data gathered, including graphs prepared and explained; on answers to the questions. A sample graph is provided from "Solar Energy Project" of the State Education Department of New York. This activity is an adaptation of one included in their 1979 publication.

Encourage "outside research" on solar collectors and answers to question 6. If possible, identify a local contractor, utility or business representative who can provide information on types of solar collectors now in use and possibilities of jobs making or servicing them. Have this person visit the class or suggest a time when students may visit or telphone to obtain additional information.

The hole-punching routine is based on the assumption that you have 25-30 cm long Celsius thermometers already in stock. If reliable small thermometers are available (for example, those from A.S. & E., 955 Massachusetts Ave., Cambridge, MA. 02139 for about $.71 each) and if all you cover materials are transparent, holes may be unnecessary. The thermometer can stand inside the can or box and be read through the cover. Eliminating holes means that opaque covers cannot be tested, but another variable may be introduced instead. Water or other liquids may be used for the collecting fluid.

SOLAR COLLECTORS:

A collector for a solar heating system has five basic parts:

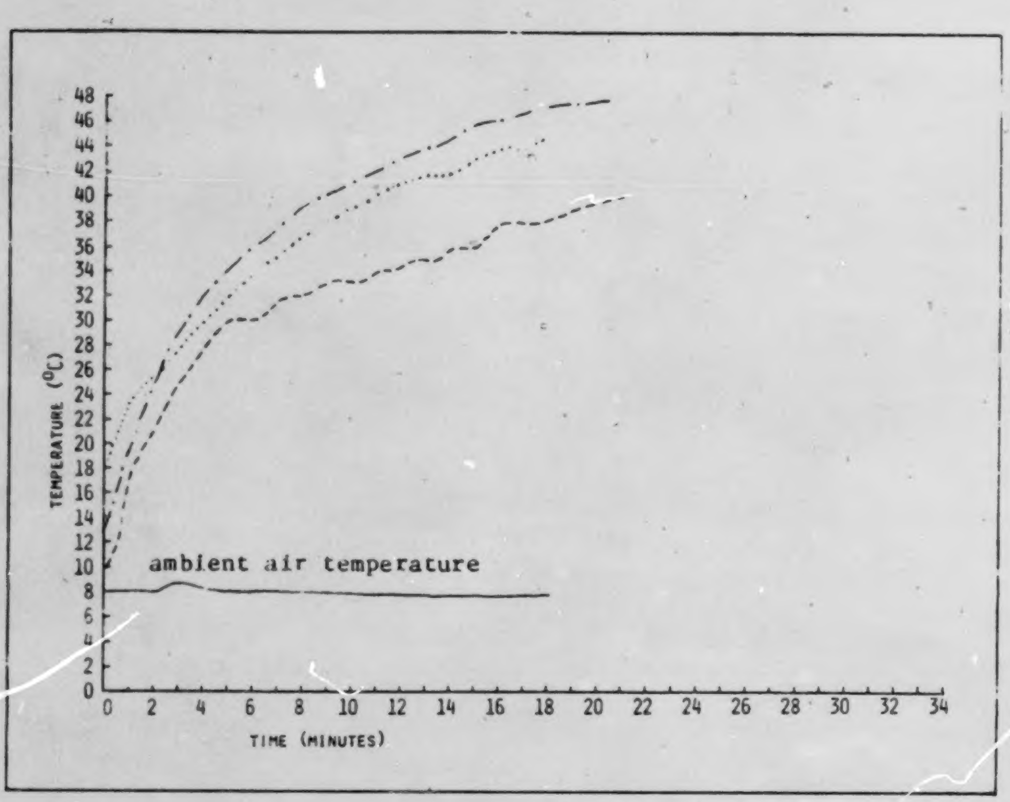
1. The cover or glazing material which (ideally)
    lets in almost all of the incoming solar radiation;
    does not let energy out again;
    is unbreakable;
    can withstand a wide range of temperatures without cracking or decomposing.

2. The collector plate which absorbs the energy admitted by the cover and
    is usually metal (copper and aluminum are typical choices);
    is almost always covered with a dark coating that has to be stable at high temperatures.

3. The housing or collector box surrounds and/or supports the other parts of the collector;

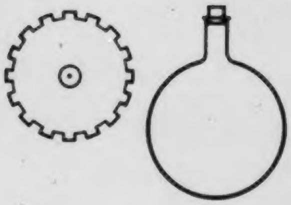
4. The insulation surrounds all unglazed sides of the collector box in order to reduce conduction losses;

5. The fluid (either air or a liquid, commonly water and antifreeze) which transfers solar heat to another substance to be heated (air in living areas or a storage medium).



Sample graph for CANNED SUNSHINE

Symbol	Insulation Type	Inner Cover	Outer Cover
__.__.	styrofoam	clear plastic	clear plastic
......	rock wool	clear plastic	clear plastic
------	fiberglass	glass	none



Color It Hot

Objective:

To demonstrate the reality of heat energy in water.

Materials:

Two identical glass canning jars or beakers
About 500 ml of water prechilled in the refrigerator.
Food coloring in plastic squeeze bottle or conventional bottle + dropper
Hot plate, electric teakettle, Bunsen burner, immersion heater, or other device to heat about 500 ml of water to boiling.
Clock or watch

Procedure:

Put the glass containers near each other (but not touching) on a level table. Boil enough water to nearly fill one of them. When the water is ready, pour it into one jar. Then pour an equivalent amount of chilled water into the other container. Add one or two drops of food coloring to each. Observe similarities and differences.

Questions:

1. How long does it take for the food coloring to spread evenly throughout the water?
2. How are the contents of the two jars alike?
3. How are they different?
4. Explain your observations.

Teacher's Guide to Color It Hot

This can be done as a quick demonstration or it may be done individually by students, depending on time and facilities available to you.

Preparation:

Be sure to chill some water in advance, preferably overnight. Better yet, chill the water and the jar you are going to use for the demonstration. Also, pre warm the "hot jar" by pouring in hot tap water or some of the boiling water--let it sit a minute, pour out the water, and refill to the same level as the chilled water.

Expected Results:

The hot water will become uniformly colored within seconds. In cold water, the food coloring diffuses very slowly and may not be evenly distributed even after a 40-50 minute class period.

Encourage student comments. Some typical observations will be that hot water is different from cold, that heat helps move things (food coloring), that heat speeds reactions, that hot water has more free energy to give to the food coloring, that molecules move faster when warm.

Energy Word Games

1. ENRGY Bingo

Ordinary bingo requires only the ability to hear numbers called, to recognize them on a card, to cover them on the card when called, and to say "Bingo!" when five adjacent numbers are covered in a row, column, or diagonal. ENRGY requires additional skill: Knowledge of some energy-related terms. The objective is to enhance retention of what the student has learned about energy, to motivate learning additional facts, and to point out gaps in knowledge.

a. Advance preparation:

Cards must be developed like the following example. No two should be exactly alike. Words from the accompanying list are suggested. Add others that are appropriate for your classes.

Also, prepare in advance a short descriptive sentence for each energy-related word used on your game cards. Put each sentence on a separate slip.

b. Play:

To begin play, the caller will shake up the word slips in a 3 lb. coffee can or other suitable container. Then he will draw and read one slip at a time. Players must decide which term is being described and, if they have that word on their cards, cover it. From then on, it is played just like conventional bingo.

E	N	R	G	Y
evaporate	entropy	R-factor	geothermal	hydropower
conduct	nuclear	recycle	gas	bicycle
convect	fusion	FREE	coal	flywheel
electric	fission	retrofit	petroleum	Calorie
EER	insulate	radiation	quad	fuel

2. Crossword puzzles and word-maze games

Provide graph paper with 1/2 inch or cm-squares. Encourage students to make word puzzles using

a. as many "energy words as possible; or
b. as compact a format as possible (measured in ratio of squares used/squares available); or
c. a graphic energy-related design within which selected words will "fit"; or
d. a special theme, like travel, houses, electricity, conservation, alternative sources, etc.

3. Charades

a. Advance preparation:

Have energy vocabulary written onto separate slips of paper or file cards and placed in a shoe box or a 3 lb. coffee can.

b. Play:

A student will draw out one of the energy terms. This student must pantomime or find a way to describe his energy-related feature without saying anything. Some fingerspelling may be allowed. The student who first guesses the term in question will then get the privilege of drawing out another slip of paper and repeating the process for a different energy word.

4. Password: Energy Style*

a. Advance preparation:

Make 3 clue cards, one large one to show the audience and 2 small ones, one for each team. (The card goes only to the contestant giving the clue.) Use heavy paper so writing will not show through. Use the ENERGY WORDS FOR GAMES or any others of your choice.

b. Play:

Bring four students to the front of the classroom and have them alternate giving clues and receiving clues (two teams). Give points according to how many clues have been given--10 for the first clue, 9 for the second clue, and so on down to 1 point before you reveal the word to the guessing partner. Game is 21 points.

**This is one of a group of learning games suggested by Miriam Colvin of Hawkeye, Iowa; Dorothy Kruse of New Albin, Iowa; and Ada Narem of Meservey, Iowa in an energy unit developed during a DOE-sponsored workshop directed by Ella Jedlicka at U.N.I., Cedar Falls, Iowa, June 1978.*

5. Riddles

Have students (individually) write words that are descriptive of or associated with some energy source, energy use, energy effect, or energy-related technology. Then ask each student to rank these "word-clues" from easiest to most difficult (a scale of 1-10 is suggested) and to rewrite them in that order.

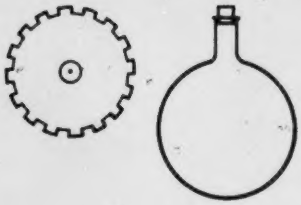
Students can then test these riddles on each other, supplying the most difficult clue first (ten points to receiver who is successful on this one) and the rest in order, with easiest last (only one point for guessing correctly on the last clue). Have class look for the most interesting and most challenging riddles. Students who (unknown to each other) had chosen the same words to "riddle" may refine their clues to incorporate the best of each. Or others in the class may have suggestions for perfecting the riddles. Encourage combinations and additions. Then have students rewrite their clue lists and arrange to have the riddles used in another class. Prepare an appropriate prize for the contestant who answers most efficiently (that is, using least clues). An example of a "sequential clue" riddle is:

Clue	Points
distant	10
diffuse heat	9
fusion	8
bright	7
daily	6
favors equator	5
trapped in plants	4
worshipped by many	3
life source	2
fireball	1

Answer: The SUN.

ENERGY WORDS FOR GAMES

air conditioning
air pollution
appliances
atom
barrel
bicycle
boiler
brown out
BTU
Calorie
car pool
caulking
Celsius
coal
coal gasification
condenser coil
conduction
conservation
consumer
convection
coolant
critical mass
damper
EER
efficiency
electricity
energy
energy transition
entropy
evaporation
exchanger
Fahrenheit
fiberglass
filters
fireplace
fission
fluorescent
flywheel
food chain
forced air
fossil fuels
friction
frost free
fuel
fuel cell
furnace
fusion
gasket
gasoline
generator
geothermal
heat
heat pump
horsepower
hot water
hydroelectric
incandescent
infiltration
insolation
insulation
internal combustion
joule
Kelvin
kilogram
kilowatt
kinetic energy
lifestle
megawatt
meter
methane
natural gas
nuclear power
oil shale
overhang
peak load
petroleum
photosynthesis
potential energy
pressure cooker
propane
quad
R-factor
radiation
radioactivity
recycle
retrofit
solar
solar collector
specific heat
storm window
styrofoam
sun
temperature
thermal efficiency
thermal pollution
thermometer
thermostat
triple pane
vapor barrier
waste
weatherstrip
wind break
work



Go With the Flow: Thermometers and Heat

Background:

When you feel cold on a wintry night, it seems natural to curl up under a warm blanket. On the other hand, when warm nights come in summer, it feels good to stretch out, throw off covers, and move around to catch a breeze.

Most materials behave in a similar way. They shrink (contract) when cooled and stretch out (expand) when warm. In fact, the degree of stretch or shrinkage can be a measure of the average heat of the surroundings. All thermometers work on the basis of materials responding to heat flows. They lose heat to cooler surroundings and gain heat from warmer ones. The following activities involve making simple thermometers that demonstrate how three different materials move in response to heat.

Activity I: Water Thermometer*

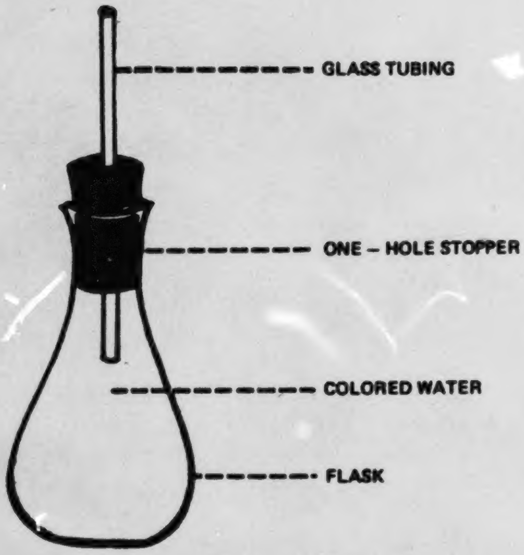
Materials:

Erlenmeyer flask or any bottle with a neck that can accept a one-hole rubber stopper
Rubber stopper with one hole
6" glass tubing
Food coloring, water
Thermometer

Procedure:

Fill the flask with water. Add food coloring to make the water easier to see.

Using liquid soap or vaseline as a lubricant, fit the glass tubing into the rubber stopper so that the lower end barely extends beyond the stopper bottom.



WATER THERMOMETER

**Adapted from Jerrold W. Maben, How Far a Star. Washington, DC: N.A.S.A., 1969.*

Put the stopper into the flask as shown in the sketch, forcing out any extra water.

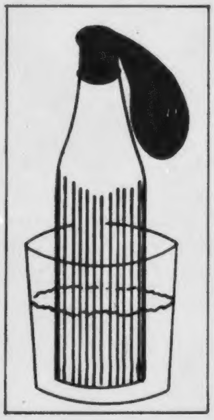
Mark the water level in the glass tube with a grease pencil or magic marker and note the temperature on a standard thermometer. Compare your device with those of classmates. Is the water level the same in all?

Expose the water thermometer to as many different conditions as you can . . . sunny window, shady corner, refrigerator, oven on low setting (no more than 200°F or 95°C), candle flame, or warmth from your own hands. Mark the water level for each of these conditions. Also compare the behavior of the school-provided thermometer under the same conditions.

Questions:

1. Does the water level in the glass tube change when the homemade thermometer is exposed to different conditions? Explain.
2. How is your water thermometer like the standard mercury one?
3. How is your thermometer different?
4. Why is mercury or alcohol usually used in outdoor thermometers instead of water?

Activity II: Air Thermometer



Materials:

Pop bottle, ketchup bottle, or Erlenmeyer flask
Balloon
Hot water, ice
Liter beaker, small pail, or similar container.

Procedure:

Stretch the balloon opening over the mouth of the bottle. Set the bottle in a pail or beaker of boiling hot water. Either describe in words or make a picture of any changes in the balloon.

Next put your air thermometer into a beaker or pail of ice water, or into a refrigerator. Describe what happens to the balloon in words or make "before" and "after" sketches.

Questions:

1. Explain what happened to the balloon under the various conditions.
2. How could you calibrate (mark levels on) an air-balloon thermometer?
3. How could you make an air thermometer that would be more sensitive to temperature changes than the one you have?
   (You may look in some science books or encyclopedias for clues.)

38

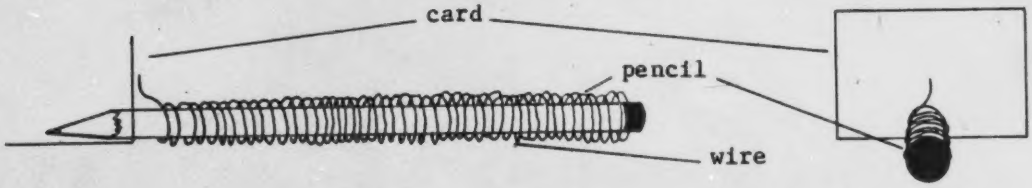
Activity III: Wire Thermometer

Materials:

2 m of fine, uninsulated wire
Pencil
Small piece of stiff paper or file card

Procedure:

Wrap the wire carefully around the pencil, leaving one end bent outward.



Fold the card in half. Open it so that one half is at a right angle to the other. Use half for a base. Make a small hole near the fold edge (on the upright half) to slip the pencil through so that the end of the wire is outlined against the card. Mark position of this end wire.

Put your wire in the refrigerator or freezer, card and all. Position it so that the pointer and card are easy to see when you next open the door. Let it rest for ten minutes; then reopen the door and mark the position of the end wire.

Next, put your wire thermometer in an oven for ten minutes (on moderate heat, about 300°F or 150°C). Note the position of the end wire as soon as you reopen the door.

Questions:

1. How could you change the design or materials of your wire thermometer to make it useful over a wider range?

2. Which would be most useful in everyday life, a liquid, gas, or metal thermometer? Explain.

3. What material is used in most weather thermometers? Why?

Extensions:

1. Find out who some of the first thermometer makers were, what their devices were like, and for what purpose each device was invented.

2. Compare and contrast several temperature scales--Reamur, Celsius, Kelvin, and Fahrenheit. Where are they used, by whom, for what materials, and how are the critical temperatures determined?

Teacher's Guide to Go With the Flow

Making your own thermometer is a quick introduction to the limitations encountered in measuring temperature or the average level of heat in a local environment. The amount of heat a material absorbs before it changes volume significantly varies with each. Fluids generally respond more rapidly than solids, but thermal expansion of common building materials is recognized as a factor to be considered in constructing bridges, multistory buildings, and railroad tracks.

For everyday work, water works well at ordinary indoor temperatures but its boiling and freezing points impose limitations. Mercury is liquid over a much wider range (-39°C to 356°C).

Expected Results:

I. Water thermometer

The water level is readily raised or reduced by heating or cooling, respectively. In fact, on refrigeration the water level may go down so far as to empty the glass tube completely, making calibration impossible. This provides an opportunity to discuss the arbitrary nature of temperature scales (they are all relative, but water is the direct or indirect standard for each).

It may be worth noting that air pressure also affects the water thermometer as constructed, so different weather systems may change the water level as much or more than temperature does. This can be seen if the homemade instrument is available for observation over several days' time. Commercial thermometers, being evacuated and sealed, do not have this sensitivity to ambient air changes.

II. Air thermometer

The balloon's change in shape and volume is easy to observe but difficult to measure. If the balloon were slightly inflated and attached in the coldest expected environment, and if markings were inked in carefully spaced intervals on its skin, the degree of expansion on warming could be measured or quantified as a function of the increased distance between those markings.

One of the very first thermometers (Galileo's) was based on the ability of air to expand when warmed by human heat radiation. One of your students may want to read about this aspect of technological innovation. Another may want to inquire at local hospitals about the temperature-measuring devices currently in use there, and report on their advantages. Encourage comparisons of the two. Were they equally useful? limited in application? energy-expensive or inexpensive?

40

III. Wire thermometer

Changes are small compared to those observable with fluids, so making observations while the wire is still in the refrigerator or oven (before heat gained or lost is quickly equalized in the room) is important.

Total length of the wire (2 m) vs. height of the water tube (6") vs. length of the balloon may impress some students. The position of the endwire changes only because overall length is slightly changed.

The paper "dial" for marking endwire position is the most vulnerable part of the system. One made of metal and a less-flammable "core" (pencil) for the thermometer would make the instrument usable at higher temperatures.

High Cost of Living

Study of a Herbivore

Objectives:

To observe the rapid energy consumption and the growth and changes in a common herbivore.

To compare the amount of food energy consumed to the growth measured (energy stored) in a living organism.

To develop awareness of food chain energy dependencies and losses.

Materials:

Caterpillars (monarch or swallowtail or any other larvae for which food is readily available)
Wide-mouthed jars, liter beakers, or plastic ice cream containers, one per caterpillar
4"-6" popsicle sticks, tongue depressors, or twigs, one per caterpillar
Daily record sheet
Watchglass or petri dish and balance scales
Plastic wrap or waxed paper and rubber bands (unless jars have useful lids)

Advance Preparation:

If you are collecting your own caterpillar, look for milkweed, Queen Anne's lace, carrots, or parsley leaves. Carefully examine the underside of the leaves for small striped caterpillars. Holes near leaf edges of milkweed are often a clue to the presence of a busy herbivore beneath. Small droppings on a leaf surface may be a clue to a caterpillar on a leaf above that one.

You will need to weigh small amounts of material accurately. Be sure that you know how to use a balance scale beforehand. Practice weighing a watchglass, petri dish, or small beaker. Do it three or four times and average the results.

Keep this watchglass or dish to hold small items you will need to weigh in this activity, and measure them by difference, one at a time. You will calculate the weight of the caterpillar, for example, by subtracting the weight of the empty watchglass from the combined weight of the watchglass and caterpillar on it. This weighing by difference is a useful method for measuring very small things. The container will steady the balance and help reduce errors caused by air currents, vibrations, and other disturbances.

Procedure:

Day 1. Weigh your caterpillar (as described above) and place it gently in its own container. Supply it with a 4"-6" stick (long enough to stand diagonally in the container) that you have also weighed. Weigh two or three fresh leaves of the same type your caterpillar was eating originally, and put them into the container. Cover the jar with plastic wrap, waxed paper or its original lid. Punch a few small holes in the cover. Put the jar in a quiet place where natural light changes occur (hours of light alternating with hours of darkness), but away from direct sunlight which may fry your delicate pet.

Day 2. Reweigh the caterpillar by the difference method. Weigh the remainder of its leaves the same way. Empty the droppings from the jar into your preweighed watchglass or dish. Weigh them, then discard them. Reweigh the stick. Weigh one to three fresh leaves and then put them back into the cleaned-out jar with your caterpillar and its stick. Record all your measurements.

Day 3 and following. Reweigh the caterpillar, remains of leaves, and droppings as before. Weigh fresh leaves and restock the jar. Repeat this procedure daily until the caterpillar makes its chrysalis (usually 1-12 days after you found it, depending on its maturity when first discovered). You can then weigh the chrysalis on its stick and figure its weight by difference. IF the caterpillar attached itself to a leaf, the side of the jar, the lid, or some surface other than the stick provided, do not disturb it or it will not develop normally.

Care of chrysalis: If you had a monarch caterpillar, just leave your jar with the lid off in a shady corner of the classroom. You should see some dramatic changes in about ten days, and may notice minor ones daily.

If you had a swallowtail larva, then put your chrysalis in a refrigerator, unheated storage room, enclosed porch, or protected outside area. Check it daily starting April first, returning it to the classroom at that time.

Questions:

1. How much weight did the caterpillar gain daily? Total?

2. How much leafy dinner did your caterpillar consume during the observation period?

3. Total the weight of droppings you collected.

4. Does net input, (leaves consumed) minus output (droppings), equal the caterpillar's net weight gain?

5. Explain your results.

6. Plot a growth curve (increasing weight over time) for your caterpillar.

Additional Questions:

7. How much did the watchglass vary in weight from day to day?

8. What percent of the watchglass' average weight was the largest deviation?

9. How much did the stick vary in weight from day to day?

10. What percent of the stick's average total weight is the maximum deviation?

11. Does this amount of variation in daily weighings help explain the answer to question 4? If so, how much of a factor is it?

Daily Record Sheet

High Cost of Living I
(herbivore)

Day	wt. empty watchglass	wt. watchglass + caterpillar	wt. caterpillar	daily wt. gain of caterpillar	wt. stick	wt. fresh leaves (A)	wt. leaf remains (B)	wt. leaves consumed (A_1-B_2)	wt. watchglass + droppings	wt. droppings	"E"
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Totals:											

Teacher's Guide to
High Cost of Living - I Study of a Herbivore

This activity takes some pre-planning, careful use of balance scales, and conscientious daily attention to the caterpillars for two to ten (or more) class days and possibly a weekend. The duration depends on the size and maturity of the larvae when you first get them. Since daily feeding and weighing is important, you may prefer to make this an independent activity for some students rather than a classroom project. Arrangements for use of a balance scale must be considered in advance. The amount of care and time involved is an important part of this learning experience. All energy transformations take time. There is a parallel in "energy crisis". Problems in availability of energy resources have been developing over time, and solutions must also develop over time.

Plan to do this activity early in the fall, or as soon as school is underway. Butterfly caterpillars are scarce to non-existent in Iowa after October first.

Collect containers in advance. Wide-mouthed jars (mayonnaise, peanut butter, etc.) or plastic ice cream containers or cottage cheese boxes are all usable.

Have students look for monarch caterpillars on milkweed; or look for swallowtail larvae on Queen Anne's lace, carrots, or parsley leaves. Other insect larvae with which you are familiar may be substituted; however, few have so dramatic a metamorphosis as these common butterflies.

Live butterfly culture (caterpillars and synthetic food) is available from some biological supply houses. Or, painted lady and buckeye butterfly larvae and food can be ordered locally from Unified Services for Education, 115 N. Dubuque, Iowa City, IA 52240. The 1980 price for one unit (five caterpillars and food) is $5.50. A school kit comprised of a container and mail-in coupon for 30 larvae and 8 oz. of food is $18.00.

Mealworms are a possibility since they are nearly always available. Their drawbacks are that larvae are usually nearly fullgrown by the time they are noticeable and sold so weight gain may be hard to measure; they grow very slowly so weeks may pass before any change is evident; a "control" portion of non-infested food must be kept as a check on inevitable moisture losses; the food itself is harder to handle and weigh. Calculations would be simplified somewhat because droppings cannot be isolated, but would be included in residual weight of the food.

Accurate record keeping is important for the success of this activity. A sample data sheet you may use for this activity is provided. Discuss carefully the various headings of the data sheet. Urge students to keep these data sheets in the classroom to avoid losses before the activity is completed.

Allow time for students to practice weighing if they are not already familiar with the balance scales. (Or, if you have only one or two caterpillars, you may want to do the weighings yourself as a demonstration.) Encourage students to mark and use the same watchglass or dish for every weighing. An idea of the amount of normal fluctuation involved in repeated weighings will arise out of daily variation in the weight of the "known" object. Also, time is saved by knowing the approximate weight of the usual container.

Results are expected to show loss of biomass. That is, the total weight gain of the caterpillar + weight of its droppings is less than the weight loss of the leaves (amount eaten by the caterpillar). In the conversion of the energy-rich hydrocarbons in the leaves to animal protein, much energy is used by the living organism for moving, chewing, digesting, assimilating, breathing, etc. The net energy left for storage in energy tissue is a fraction of that originally consumed.

There is no easy way to measure actual energy content of the leaves and of the caterpillars in the classroom. The direct way to do this is by incinerating the organic material in a bomb calorimeter. It is a rather complicated piece of equipment and requires a very meticulous technician to handle it successfully. Sometimes chemical or food research labs have them; some college labs may have one. If you or your students are interested in seeing one, it may be worth a few telephone calls to see whether any local industry or university has a bomb calorimeter and the personnel to put on a demonstration with it.

In this activity, then, one is assuming that the plant tissues and the caterpillar tissues contain the same concentration of energy. That is, their "energy density" is the same and their water content is proportional and neither one has concentrations of mineralized lower-energy masses (bones). If these assumptions are valid, then it is fair to say that the energy loss from leaf to insect tissue is proportional to the factor "E" needed to balance the food chain equation:

wt. leaves consumed = (caterpillar wt. gain) + (wt. droppings) + "E"

Rewriting this equation we get:

"E" = (wt. leaves consumed) - [(caterpillar wt. gain) + (wt. droppings)]

If your caterpillars were monarchs, let the chrysalises stay in their jars with lids off now in a shady corner of the classroom. If they are swallowtail chrysalises, put them in a refrigerator or other cold place (-20° to 40°F) until April 1. Then return them to the classroom in uncovered jars.

Unless they are attacked by parasites or are not securely hung onto their sticks or jars, the chrysalises will develop into beautiful butterflies. Have a brightly colored jar lid (red or orange are good) available for that day. When the butterfly emerges, put a lid with one or two dops of honey on it on your sunniest windowsill and the butterfly will find it. Do not keep your butterflies indoors more than 24 hours, however. Let them have a chance to migrate or mate on their own power.

There is the possibility of developing an analogy between energy use and development of a complex society: compare it to the energy use and development of a complex flier (butterfly) from a simple crawling bag of jelly (caterpillar). Will we ever soar under our own initiative after being such stored-energy addicts? Can we also develop "wings" to glide on the natural energy flows available on Earth's surface?

High Cost of Living -- II

Study of an Autotroph

Objective:

To observe some plant/energy relationships.

Materials:

Seeds of yellow or green wax beans (bush variety)
Sunny window
Sand, vermiculite, or potting soil
Clay flower pots, 4"-5" size, with saucers
Some pebbles or gravel
Balance scales
Aluminum foil
Oven
Small jar, beaker, or watch glass

Procedure:

1. Weigh a small jar, beaker, or watch glass on the balance scale. Record its weight. Pick out 10 look-alike beans. Add these bean seeds to the weighed jar and weigh it again. Figure weight of the seeds by differences:

   Example: Wt. beans + jar 64.9 g
   Wt. empty jar -60.0 g
   Wt. 10 beans = 4.9 g

   Then calculate the average weight per bean.

   Example: If 10 beans weigh 4.9 g, then

   $$1 \text{ bean} = \frac{4.9}{10} = 0.49 \text{ g.}$$

   Record all your figures.

2. Fill a 4"-5" diameter pot with soil or sand, first putting a pebble or piece of gravel over the drainage hole. Bury five beans in this pot, each about 1" apart and 1" deep. Repeat this procedure, putting the other 5 beans in a "separate but equal" pot.

3. Put your name and the date on the sides of your pots. Water it well and set it where it will not be disturbed for days (your teacher will tell you where).

4. Check your pot daily for dryness. Add water, when necessary, from the top. If any water collects in the saucer, remove this surplus. When sprouts first appear, put one pot in a sunny window and the other in a closet or cupboard.

5. Let sprouts grow about 30 days or until the more successful ones have at least 6-8 leaves apiece. Bush beans usually get to the flowering stage by this time in a heated classroom.

6. Then gently remove your plants from the soil, roots and all. Note the number of beans that sprouted and discard any unsuccessful beans. Rinse off the roots to remove any soil that may be clinging to them. Then lay your sun-grown plants and darkness-sprouted ones on separate pieces of aluminum foil and dry them in an oven at 80°C (176°F) for three hours or more. (If you have made a solar oven, this is a good use for it.) Or you can do the drying at home, carrying your plants in the aluminum foil. Fold it around them for easy carrying, but open up the foil to be a flat tray in the oven. Then when the remains are taken out of the oven, fold the foil carefully around them, completely enclosing the dried plants, so that
   a) you don't lose any material and
   b) moisture is kept out.

7. Weigh the dried plants (still wrapped in foil) on a jar, beaker, or watch glass. Then remove the plants and reweigh the foil and glass container. Calculate the dried biomass by difference . . .

   wt. (dried plants+foil+container) - wt. (foil+container) = wt. dried plants

8. Calculate the average weight per plant grown in each of the two conditions. Disregard any beans that failed to sprout.

9. Calculate the net difference (gain or loss from the food energy stored inthe seed) between the average bean plant and the average bean seed you planted under each of the two conditions. Record your data on the chart, and answer the questions included there also.

Optional Extended Activities:

1. If you have already built or would like to make the coffee-can calorimeter described in "CALORIES, CALORIES . . .," you can actually burn some beans and the bean plants in order to make comparisons of their caloric value. You will have to modify the set-up just a little. Eliminate the needle, but keep the cork. Use a crucible or shape an aluminum foil "boat" and set it on the cork.

49

The "typical bean" should be split in half and a little powdered charcoal added (.05 g or less . . . measurement is important as you must give the same treatment to the "typical" dried bean plant). Then ignite it, put it under the test tube of water, and record the temperature change as is directed in "CALORIES, CALORIES . . . ."

Repeat the process (with fresh, room temperature water and a cooled-down test tube) with one of the dried plants from each group being burned separately. Record temperature rise and calculate calories absorbed by the water each time.

[(Peak Temperature, °C) - (Initial Temperature, °C)]

x (Volume of water heated, ml) = calories.

Compare. Is there much difference between the fuel in the seed and the fuel in the plants? Explain your observations.

2. In order to keep track of another variable and estimate its effect in contributing to bean growth, you may want to dry the soil you use before potting it. Then weigh the amount put into each pot before planting the beans. Later, after removing bean plants and rinsing their roots directly into the pot, dry the soil again and reweigh it. Considering your results, did the soil itself contribute a measurable amount to the gain in mass of the bean plants?

3. If you have already done "HIGH COST OF LIVING - I" (study of a herbivore), compare results of plant growth in sunlight over time to the caterpillar's growth rate on a diet of leaves. Which grew faster, on a daily or weekly basis? What similarities and what differences did you notice about their enlargement? What energy transportations can you trace in their lives?

Name ______________________________

STUDENT WORK SHEET--HIGH COST OF LIVING (autotroph)

Starting Date: __________ Ending Date: __________ Growing Time: __________

	Bean Seeds			Bean Plants			Net Difference
Condition	No.	Total wt.	Avg. wt.	No.	Total wt.	Avg. wt.	(Avg. wt. plant minus avg. wt. seed)
Sunlight							
Darkness							

Questions: (Use reverse side of this paper for your answers.)

1. Explain differences between the amount of material in the seeds and in the plants.
2. Explain any differences between the weight of sun-grown plants and darkness-grown plants.
3. Which would make a better fuel, the bean seed or the bean plant? Describe a way to test your answer.
4. Where did the bean's energy come from?
5. How can this energy be released again?

Teacher's Guide to High Cost of Living II
Study of an Autotroph

One or two class periods will be necessary to get the beans weighed and planted, depending mostly on how conscientious students are about the weighing and whether or not you opt for including "Extended Activity 2" as part of the project. If you do, weighing of pre-dried soil is another time-consuming operation. However, it is a worthwhile addition. Otherwise many students are tempted to conclude that the (expected) gain in weight by the bean plants is entirely due to soil material soaked up with the water. Actually, the amount of minerals (if any) soaked up from the soil is so small as to be not measurable by ordinary classroom scales. Yet each sun-grown bean plant will likely grow to be 3-5 times the mass (excluding water) of the original seed within 30-40 days. The gain comes from gases absorbed through the leaves and combined, in the presence of sunlight, into complex carbohydrates. Although students may be familiar with the word, photosynthesis, the actual physical measurement of this solar-powered process is usually a revelation.

It is important to let the sun-grown bean plants get at least to blossoming stage. The seed alone has enough stored energy to get the young plant to a 4-leaf stage.

Expected results are that the darkness-grown plants will not show any net weight gain (dehydrated) but that the sun-grown ones will.

Like many energy-related activities, this one cannot be completed within one or two consecutive class periods. There is a waiting period of 30-40 days during which pots must be watered but do not require other attention. Energy storage takes time, even under the best collecting conditions. If some plants can be kept until bean pods and ripe seeds are produced, an even better idea of how long it takes the plant to store some of its energy can be gained.

There are at least three ways to release "bean energy"--plant the bean and let it start a new plant moving; eat it; burn it. Note the difference in time required to release the energy by each of the means. Compare the "release times" to the "production time" of "bean energy."

Then remind students of the much greater disparities between "production time" and "release time" of fossil fuels.

If students have already done the "herbivore" or caterpillar study, the difference between efficiency of the plant as an energy concentrator and that of the insect is an interesting discussion point. Direct comparison is not possible because energy input to the sun-grown plants was not wholly accounted for (the bean seed was, but not the direct solar input). However, dependence of the caterpillar on the plant pantry is obvious. Less obvious but possible to infer is that the sun-exposed plants grow and store energy in their tissues over and above that which was provided by another living energy concentrator (that is, old mother bean plant who made the seed).

Measuring Energy

Introduction:

There are many different units used to measure energy. The mix of terms used in various media can be confusing. Many of them are interchangeable, but some are not. How did such a jungle of jargon grow?

Background:

1. Various forms of energy were recognized and studied by different people in different countries. One researcher devised units for radiant energy, for example; others worked with electricity and gave their names to its measures; mechanical energy was quantified independently at a time when equivalence to other forms of energy was not recognized. We now realize that these units can be converted back and forth.

2. Two systems of measurement are involved. The eclectic British system borrowed measurement terms from many countries. The French devised a "universal one" based on powers of ten. Both systems have been widely used, with engineers in the U.S. usually using British terms like "B.T.U." and scientists using metric ones like "calorie".

3. Two different ideas, power and energy, are often used interchangeably in popular writing, adding to the confusion. Energy is the ability to make materials hotter, higher, or denser or to cause other changes. Power is a measure of how fast such transformations are done, or can indicate how concentrated the energy source is.

   There are two principal units of power, the horsepower and the watt. One horsepower is 550 foot pounds per second and a watt is one joule per second. Kilowatts and megawatts are 1,000 and 1,000,000 watts respectively, measures of flow of electricity. In order to know how much energy is used by a power source, the amount of time that power was used must be known.

   Energy = Power x Time

4. Range of the units of energy varies. Some quantify very tiny transformations (like "electron volts") and others refer to gross consumption (like "quads"). Because of the wide range of energy measurements, including splitting of one uranium atom (.0000000001 Calories) and the annual heat output of the Sun (10,000,000,000,000,000,000,000,000,000,000,000,000 Calories) a convention has been adopted to make writing and computing with these numbers somewhat easier.

   The shorthand way of expressing vary large and very small numbers is called POWERS OF TEN. One thousand (1,000) becomes 10^3 or 1 x 10 x 10 x 10. One million (1,000,000) becomes 10^6 and one billion is 10^9. The annual solar output becomes 10^{37}. The "exponent" or small raised number after the ten indicates how many tens were multiplied together (or how many 0's should follow the 1).

   Very small numbers are indicated by a minus sign in front of the exponent.

   Example:

$$\underset{\text{coefficient}}{6.6} \times \underset{\text{base}}{10}^{-8} \longleftarrow \text{exponent}$$

   The negative exponent indicates how many places to the left the decimal point should be placed. For the example above, the equivalent decimal is 0.000000066.

Common Units of Measure for ENERGY:

barrel: a liquid volume equal to 42 gallons or 159 liters or 0.159 m^3; usually used for petroleum

barrel of oil equivalent: an amount of energy typically contained in one barrel of petroleum--5.8×10^9 joules or 5.5×10^6 BTU or 1.39×10^6 Cal.

B.T.U. (British Thermal Unit): the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. One BTU is approximately equal to the amount of heat given off by a wooden match. A pound of coal contains approximately 13,000 BTU of chemical energy.

calorie: the amount of heat required to raise the temperature of one ml of water one degree Celsius.

Calorie: the kilocalorie or "food Calorie", the amount of heat necessary to raise the temperature of 1,000 ml of water one degree Celsius.

foot candles: unit of direct illumination at a given location, equivalent to the energy of light received on a surface at a distance of one foot from a standard candle. It is equal to one lumen per square foot.

foot-pound: English unit of mechanical energy, or work, the amount needed to lift one pound object one foot off the Earth.

horsepower: another unit of mechanical energy, the equivalent of 33,000 ft.-lbs. of work per minute (or 550 ft-lbs. per second) or 42.4 BTU's per minute. In electric power units, one horsepower-hour is about 0.75 kilowatt-hr.

joule: a metric unit of work, mechanical energy, and heat; approximately equal to 0.74 ft.-lbs. or 0.00096 BTU or 0.24 calorie. It is defined as the energy needed to raise a one kg. object one meter off the earth. It is also defined as the energy expended in one second by an electric current of one ampere in a resistance of one ohm.

kg coal equivalent: unit of heat energy often cited in U.N. statistics for comparison of solid, liquid and gaseous fuels. One kilogram coal equivalent is 7,000 Calories or 28,000 BTU.

Langley or Ly: unit of solar energy, radiation intensity equivalent to 1.0 calorie/cm^2. It can be used as a power unit when flow over time is expressed as Ly/min. or Ly/hr. or Ly/day. One Ly/min. = 221.2 BTU/hour/ft^2. One ly/min. also = 697.3 watts/m^2 or 16.74 kwh.

quad: the gigantic energy unit used to measure how much entire countries consume each year; it represents a quadrillion BTU's or the amount of energy in 172 million barrels of oil. United States citizens used about 78 quads of commercially supplied energy in 1979.

watt: a measure of electrical power, one joule per second. Wattage is a product of the voltage (measure of the "pressure" in an electrical circuit) and the amperes (current or flow of electricity). One volt and one amp applied to a circuit for one hour would use one watt-hour of electricity. One thousand (1,000) watt-hours or a kilowatt-hour is the unit most often used to measure electrical consumption. A 100 watt bulb burning for one hour has used 100/1,000 or 0.1 kwh of electricity. The same bulb lit for ten hours would use ten times as much power or one kilowatt-hour.

Activity Suggestions:

1. Use copies of Energy Unit Conversion Charts A and B for students' practice in handling "powers of 10". Provide Chart A and ask the students to rewrite each conversion factor in exponential form. Another day use Chart B as an "exam", asking students to rewrite each factor as a conventional integer or decimal.

2. Have students look through DOE pamphlets, extension service and utility company brochures and reports, popular magazine articles on energy topics, home utility bills, appliance handbooks or tags, science textbooks, and other available literature for examples of common usage of energy units

56

a. Which unit(s) appear most often? Why?

b. Which is easiest to visualize or otherwise remember? Why do you think so?

c. If you could "standardize" energy units, what measurement would you use? Give a reason for your choice.

d. Why is it important to measure energy anyway?

3. Using mail order catalogs, appliance owners' handbooks, and automobile owners' manuals, identify the energy and power units used to describe various movers, heaters, and lights. Which items require the most energy for their use (daily, weekly, yearly)? Which require very concentrated energy sources? Which could operate or be made to operate on renewable resources?

Energy Unit Conversion Chart A

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal		4,200	.0012	3.97	3,090	.00156
joule	.00024		.00000028	.00095	0.74	.00000037
kwh	860	3,600,000		3,400	2,700,000	1.3
BTU	.252	1,055	.000293		778	.00039
ft.-lb.	.00032	1.4	.00000038	.0013		.0000005
hp.-hr.	640	2,700,000	0.75	2,500	9,980,000	
barrel of oil equivalent*	1,386,000	5,800,000,000		5,500,000		

Note. *Numbers have been rounded to two significant figures in most cases. Calorie is the kilocalorie or "food Calorie."*

**42 U.S. gallons.*

Energy Unit Conversion Chart B

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal.		4.2×10^3	1.2×10^{-3}	4.0	3.1×10^3	1.56×10^{-3}
joule	2.4×10^{-4}		2.8×10^{-7}	9.5×10^{-4}	0.74	3.7×10^{-7}
kwh	8.6×10^2	3.6×10^6		3.4×10^3	2.7×10^6	1.3
BTU	2.5×10^{-2}	1.1×10^3	2.9×10^{-4}		7.8×10^2	3.9×10^{-4}
ft.-lb.	3.2×10^4	1.4	3.8×10^{-7}	1.3×10^3		5.0×10^{-7}
hp.-hr.	6.4×10^2	2.7×10^6	0.75	2.5×10^3	2.0×10^6	
barrel of oil equivalent*	1.4×10^6	5.8×10^9		5.5×10^6		

__Note__. All figures are rounded to 2 significant figures.

**42 U.S. gallons.*

Plants and Light Energy - I

Background:

No scientist has been able to make food just by mixing carbon dioxide, water, and chlorophyll together in the presence of light. Yet green plants do it all the time. The food they make provides all animals and non-green plants with energy necessary for existence.

Green plants are also the basis of nearly all the fuels man uses: coal, oil, gas, wood, peat, and alcohols. Plant sugars, starches, oils, and fibers store radiant solar energy in their organic molecules. Natural processes concentrated this stored energy into valuable fuels.

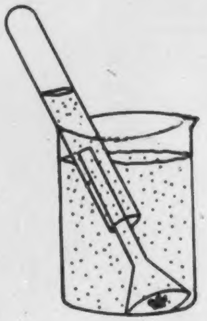
Man has lerned to control decomposition of some plant materials, capturing the by-products for fuel. Methane, for example, has been produced from sewage sludge and from animal manure. Alcohols can be obtained by fermentation of any carbohydrate-rich crop. Petroleum-like fuels can also be squeezed from some naturally oily shrubs and seeds. All of these renewable fuel production strategies depend, however, on plants to first trap and store energy by photosynthesis.

In the past, the present, and the future, humankind depends on the energy transformations in photosynthesis.

Photosynthesis is a complex process. (See a biology text for some details.) It is often described by a simple equation, however, that mentions only its basic input and a typical output:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 \uparrow$$

In plain words, the symbols say that six units of carbon dioxide combine with six units of water to form one unit of glucose (a basic sugar) and six units of oxygen gas. Light and chlorophyll must also be "on hand" for this to happen.



Activity:

Set up a demonstration to show that photosynthesis occurs only under the conditions stated. Use yeast as an example of a non-green plant and Valisneria, elodea, or other aquarium plant for comparison. Confine the plants in identical beakers of aged tap water (water that has set in an open container overnight), using test tubes and funnels as shown.

Prepare six such set-ups: two each for the green plant, two for yeast, and two for plain water. Mark the water level in the test tubes with a piece of masking tape or a grease pencil.

Put one of each kind of combination into a dark cupboard, and put the other three set-ups in a well-lit area of the classroom.

Leave all set-ups undisturbed for three to seven days. Then note the water level in the inverted test tubes.

Results:

The beaker in light that has the green aquarium plant should show a decrease in the water level (increase in "air" space) in the test tube. This is indirect evidence that photosynthesis has occurred, since oxygen (gas) is an expected by-product. In fact, students may notice bubbles forming and rising occasionally from the surface of the plant. No change or much less change* is expected to be noticeable in any beakers containing yeast or sterile water and in the dark-stored beaker with the second green plant.

**Changes in atmospheric pressure may affect the water levels slightly, but should change all set-ups alike if all variables (size of beaker and tubes, size of plants, volume of water, and yeast, etc.) were controlled.*

63

Plants and Light Energy -- II

Introduction:

Many alternative energy strategies depend on direct physical conversions: wind turning, waves moving, sunlight generating current in certain materials, geothermal heat producing steam, atoms colliding. However, some proposals rely on living cells to grow and store energy in the presence of radiation. Commercially-grown algae, for example, could feed fish for human food; could be dried and used directly as flour for bakery products; could be fermented into alcohol or anaerobically converted to natural gas.

Abundant sunlight and sufficient minerals in water are requisites for natural growth of algae. Attempts to produce algae under artificial light have been disappointing so far. The algae does grow, but much more energy input is required than the plants can capture. The amount stored for future use (regardless of the nature of the radiant energy source) is a fraction of the input. Yet all other living things depend on this fraction of stored energy uniquely converted from light to food by plants.

Objective:

To demonstrate that energy flows from source to consumers.

Materials:

Chlorella (algae) and Knops solution
or
Green pond water
Glass jars or aquaria

Procedure:

Set up at least four glass jars or aquaria, putting the same amount of algae and minerals in each or the same amount of green pond water.

Place one aquarium under a lamp (fluorescent gro-lite if available) 24 hours a day. Put a second one under the same kind of lamp but connect it to a timer that will provide 8 hours of light daily, and a third one that will get light 16 hours daily. Put a fourth one in complete darkness.

Leave the aquaria undisturbed for 3-4 weeks. Then record any differences. The intensity of the green color can indicate differences in the quantity of plant life.

A quantitative measurement may be made by organizing a serial dilution using green food coloring. Make successfive solutions one-tenth the concentration of dye in water as the preceding solution. By comparing these defined standards to the water in each aquarium, the relative quantity of the algae may be estimated. OR, the weight of organisms may be obtained by centrifuging samples from each aquarium, in pre-weighed test tubes, decanting the supernatant liquid, and weighing the test tubes again, figuring the weight of living matter by difference.

Artificial sources of illumination are recommended in order that the energy input can be measured.

$$\text{Kwh} = \frac{\text{amps x volts x hours of use}}{1000} = \frac{\text{watts x hours of use}}{1000}$$

Conclusions:

Graph the relationship between quantity of energy and quantity of organisms produced.

Make a general statement about the relationship between growth of aquatic organisms and light that is supported by your observations.

Would your results have been different if snails or small fish were part of the original set-ups? Explain.

Was your set-up a good model of the natural world? Support your decision with specific examples or limitations.

Extension:

Make a poster, cartoon, song, skit, or model of the flow of energy in the biosphere. Use Life Nature Library, biology texts, environmental information, or other resources available at your school or library.

Teacher's Guide to Plants and Light Energy -- II

Try to place all aquaria on an inside wall, away from sunlight or any other heat source that may interfere with algae growth. Optimum temperature for most kinds of algae is 68°F.

Knop's solution for culture of algae is prepared from distilled water and certain salts as follows: Pour four equal portions (250ml each) of distilled water into separate beakers. Carefully weigh out each of these items:

0.10 g. $MgSO_4 \cdot 7H_2O$

0.20 g. K_2HPO_4

1.00 g. KNO_3

0.10 g. $Ca(NO_3)_2 \cdot 4H_2O$

Dissolve each of these salts into a different one of the water samples. Then combine the four solutions, adding the $Ca(NO_3)_2$ solution last. Make a fresh solution of 4% $FeCl_3$ and add one drop to the liter of culture solution. Then dilute the entire mixture by adding another liter of distilled water to it before using it as a culture medium.

To make the serial dilutions for estimating relative concentrations of the algae in the test jars, start with an arbitrary 100% solution. To 100 ml of distilled water, add a couple of drops of green food coloring (enough to make a color noticeably more intense than that of the algae culture). Line up a series of small test tubes on a rack, or a group of small bottles. Put 50 ml of the colored water into #1.

To another 10 ml of the colored water, add 90 ml of pure distilled water. Put half of it into #2; this is the 10% solution.

Take another 10 ml of the remaining 10% solution and add 90 ml of distilled water. Put half of this dilution into #3 for a 1% solution.

Take 10 ml of the remaining 1% solution and add 90 ml of distilled water. Put half of this dilution into #4 for a 0.1% solution.

Make additional dilutions as may be indicated by the algae growth (or lack thereof). Use these graduated solutions as standards to allow some quantitative assessment of the relative growth of these aquatic plants under various lighting conditions.

66

Popsicle Power

Objective:

To observe heat flow and differences in heat storage ability (specific heat) of various fluids.

Materials:

(Minimum for demonstration-type set-up. Increase the number if used by students as an individual lab activity.

Each student would then need one popsicle and jar and be assigned a fluid--air, alcohol, water, or salt water. Data would be shared for comparisons.)

Four 7 oz. styrofoam cups
Nine small, accurate thermometers (AS + E basic ones are good)
Four identical glass jars with wide-mouths (mayonnaise or peanut butter jars are good or liter beakers are O.K.) and insulated lids, or newspapers or books for covers
Freezer
Alcohol (ethanol or isopropyl from the chem lab or high quality rubbing alcohol from a drug store)
7% salt water (70 g salt in one liter water)
Tap water

Advance preparation:

The day before this activity is scheduled, put 100 ml of H_2O and 1 AS + E thermometer (or other small, sturdy thermometer with conventional range) in each of four styrofoam cups. Arrange to have the thermometer freeze in the center of the cup. Place all the cups in the freezing compartment. Next day, remove the "popsicles' by breaking away the brittle styrofoam cup.

Make up the salt solution ahead of time and set it and some tap water aside to come to room temperature before starting the activity.

Procedure:

Lay one thermometer on the desk or table top near the jars, but touching none of them. Record the "room temperature". Tape a small thermometer to the inside of each jar with its bulb just touching the bottom of the jar. Read the temperature and record it. Then put one of the "popsicles," without its styrofoam jacket, into each jar, keeping it from touching the thermometer on the jar wall.

To one, add nothing else. Put on an insulated lid or a book over a plastic-wrap cover. Assign a student to read both thermometers (in the popsicle, and on the jar wall) every minute for 15 minutes, and another to do the same for the "room temperature" thermometer.

Ask the student to take the temperature of 100 ml of alcohol. Then pour the alcohol into the second jar and cover it like the first one. Assign another student to record temperatures of the two thermometers in this "system" every minute for 15 minutes.

Have another student take the temperature of 100 ml of tap water. Then pour it into the third jar, cover it like the others, and record temperatures as above.

A sixth student may record the temperature of 100 ml of salt water, pour it into the fourth jar, cover it like the others, and record temperatures in the same manner.

Encourage students to record any other observations during the time allowed . . melting? condensation? fog? Make graphs of the results to show the change in temperature over time of the jar wall thermometer in the four fluids (air, alcohol, tap water and salt water).

Questions:

1. Which jar had the lowest temperature after 15 minutes?
2. What factors were kept the same (controlled) in the four set-ups? What one factor varied from one set-up to another?
3. Where did the original heat of the "system" go?
4. Try to give some explanation for the temperature readings of the popsicle thermometer.
5. Based on these results, which fluid is the best "heat sponge" or heat storage medium?

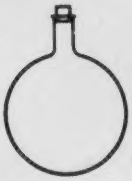
Teacher's Guide to Popsicle Power

The air temperature inside the jars will drop rapidly during the first two to four minutes and then level off. The "popsicle" temperature remains near 0°C. It appears that some heat is "lost" from the fluids without any noticeable gain by the popsicle or by the "outside" thermometer either.

The glass jars with insulated lids do a reasonable job of keeping room warmth out of the "popsicle system". When room temperature is approximately 25°C (78°F), it may be an hour before any visible melting occurs in the "all air" environment. Students will not notice any in 15 minutes. So the question is where did the extra heat come from in the other jars to start melting the ice? One may infer that there was more heat available in alcohol and in water than in air. Students may avoid this interpretation, though, because the initial temperatures of all these fluids were the same. Here is a good place to try to distinguish between heat and temperature.

The ability of materials to absorb heat is an individual characteristic of each. The amount of heat necessary to raise one gram of a material 1°C is called "specific heat". For liquid water, that unit is one calorie. For most other substances, that unit is some fraction of a calorie. So a group of materials at the same temperature do NOT contain the same amounts of heat, gram per gram or pound for pound. This concept is important in choosing materials for heat storage systems.

When any material is melted or vaporized, much extra heat is absorbed at the melting or boiling point without any change in temperature of the material. Conversely, on condensing or freezing, materials release stored heat to the environment without changing temperature themselves. Water, the most widely available "heat sponge," absorbs or releases 80 cal./g as it melts or freezes (the choice of behavior depending on availability of environmental heat or lack of it). Water even more dramatically exchanges heat at its boiling point-- 540 cal./g. These "phase changes" are very important when heat storage is desired, as in solar heating systems in particular. Eutectic salts and paraffin are sometimes used because their melting/freezing temperatures and accompanying peak of heat storage and release lie in the 29° - 49°C (85° - 120°F) range which is easily obtained by solar collection, even on cold winter days.



Potential Energy in Sugar

An Exothermic Demonstration

Background:

Sugar is a concentrated energy source as weight watchers may know. It can be called "white coal" and shown to change to charcoal with a tremendous release of heat. Add a few drops of concentrated sulfuric acid to granulated sucrose on a pyrex watchglass or a small pyrex beaker.

Or, do the following demonstration carefully.

Materials:

Small pyrex beaker
Mixture of potassium chlorate and sucrose
  (table sugar) in equal proportions
Concentrated sulfuric acid
Asbestos pad or other heat-resistant surface

Procedure:

Put about 10 g of the potassium chlorate/sucrose mixture in a beaker and place beaker on the asbestos pad. Add one or two drops of concentrated H_2SO_4. Stand back in case there is a little splattering at first.

Be prepared to discuss the source of the heat released. Where did it come from? How was it stored in the sugar molecule? What similar molecular configurations also hold great potential heat?

Extended Activities for Students:

Suggest that students get information about and report on one of the following topics regarding sugar as a food-energy source.

1. Is it or is it not nutritious for humankind? What are the facts and what are the assumptions that pro- and anti-sugar advocates use to support their arguments?

2. How many kinds of sugar are there? How do they differ in chemical composition, activity, physical properties? Are sugars the only sweeteners human tastbuds can appreciate?

3. Differentiate the sources of sweetness in corn syrup, molasses, honey, fructose, table sugar, and saccharine. How are they alike? different? rated as human energy sources? rated as potential non-food fuels?

Teacher's Guide to Potential Energy in Sugar

Some chemists speculate that reactions between certain chemicals that release large quantities of heat (exothermic reactions) may be considered as energy sources in the future. Sulfuric acid, in particular, has an established production technology and is relatively inexpensive. Possibly it can be used in some kind of corrosion-resistant heat pump.

Other chemicals are notably endothermic, absorbing heat as they combine and thereby chilling the immediate environment. Could this kind of energy sponge be used for emergency, short-term refrigeration? Or could investigation of these phenomenon suggest less energy-expensive ways to keep heat in or out of selected areas? What about the potential for making carbonated beverages (as in Fizzies)?

The following example of an endothermic reaction is recommended as being safe, with no dangerous or smelly fumes being released.

Dissolve 10.5 g of citric acid in 50 ml of water. To this solution add 12.6 g of sodium hydrogen carbonate ($NaHCO_3$, sodium bicarbonate). A temperature drop of approximately 20°C will be quickly noted.*

**Reference: Britton, G. C. et.al. School Science Review, vol. 60, pp. 99-100, 1978.*

Power Puffs

Objective:

To demonstrate efficiency of an electric heater; to observe characteristics of heating and cooling of water.

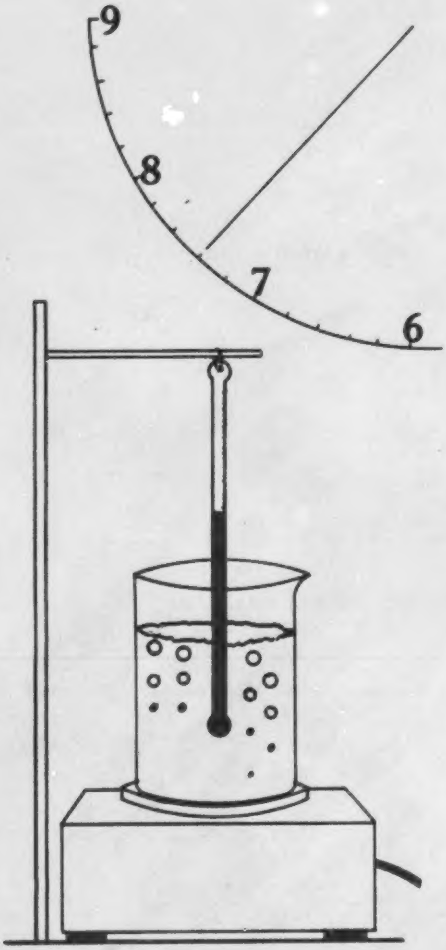
Materials:

Electric hot plate
Thermometer (0-100°C range)
500 ml pyrex beaker or
  other heatable container
300 ml water
Clock or watch with
  second hand

Procedure:

Check and record the power rating of the hot plate before using it. Put the beaker with water on the hot plate and hang the thermometer in the water so that it doesn't touch the glass.

Turn on the hot plate. Note time and starting temperature of the water. Record the water temperature every minute for 15 to 20 minutes (water should be boiling). Then turn off the hot plate and continue to record the water temperature as the water cools.



Questions:

1. Make a graph of temperature vs. time. Explain any changes in direction of the line.

2. Calculate the calorie exchanges during the first six minutes (1/10 hour) of heating.

   Subtract the beginning temperature (T_1) of the water from the ending temperature (T_2) in °C and multiply by the volume of water (300 g or 300 ml) to obtain the heat energy absorbed by the water (in calories).

   Reminder: One calorie is the amount of heat required to raise the temperature of one gram of water 1°C. A food Calorie is 1,000 calories or the amount of heat necessary to raise one kilogram (one liter) of water 1°C.

   a. The temperature change observed in the first six minutes was ____°C x 300 ml water = _____ calories absorbed by the water.

      Then multiply the power rating of the hot plate (in watts) times the time of operation (in hours) times a conversion factor of 860 calories/watt-hour to obtain the total heat energy used in operation of the hot plate (in calories).

   b. During the first six minutes, the hot plate used _____ watts x 1/10 hour x 860 = _____ calories.

      The efficiency of the hot plate operation can be expressed as a ratio between $\frac{\text{heat absorbed}}{\text{heat provided}}$ x 100%

   c. The heat absorbed by the water (a) __________ ÷ heat provided by the hot plate (b) __________ x 100% = ____________% efficiency of operation.

   d. Where did all the heat from the hot plate go?

3. Do the same kind of calculations for the entire heating period (1/4 or 1/3 hour, 15 or 20 minutes).

4. How do your results in question 3 compare to calculations in question 2? Explain any differences.

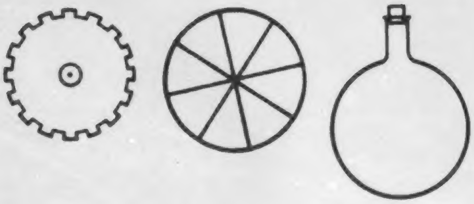
5. What do your observations suggest about boiling?

6. How could you improve the efficiency of your water-heating system?

Suggestion for extended activity:

Heat, boil, and cool some other liquids (isopropyl alcohol, salt water, vinegar, a 50-50 mixture of distilled water and alcohol) and graph their temperature-time curves. Do they heat at the same rate as water, boil the same way, cool like water?

73



Renewable Vs. Non-Renewable Energy

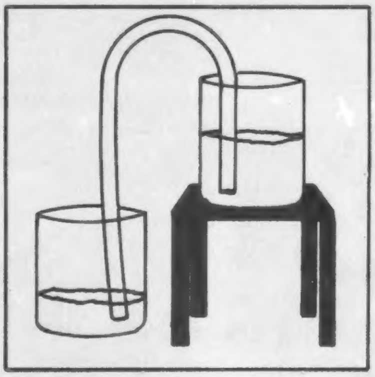
An Analogy

Materials:

Two or three pieces of flexible tubing or hoses of different diameters
Two large jars, aguaria, buckets, or other waterproof containers of similar size
Stopwatch or any watch or clock marking seconds
Water

Procedure:

Set one container on a desk or table and fill it nearly full of water. (If you want to do a quantitative analysis, measure or have students measure how much water is used.) Put the other container on the floor nearby. Fill one of the pieces of tubing (medium diameter) with water. Put one end under water in the upper container, as shown. Hold the other end closed until it is lowered into the floor-level container. Have a student secretary record the time as you release this hose and water begins to flow into the lower container. Instruct the secretary to also record the time when the water stops flowing.



Discussion:

Compare the water flow to energy flow. Consider these questions.

1. "Can the reservoir be refilled?" Literally, in the case of water or hydropower, it will be refilled if rains come periodically as expected. In the case of fossil fuels, no, nature's rate of manufacturing coal and petroleum in particular is so slow that it seems like "never" to humankind. In the case of uranium ores, the answer is also "no." In the case of sunshine, yes, the reservoir is likely to be refilled nearly everyday for billions of years.

2. "Can the flow be slowed?" Yes, use narrower tubing to make a given amount of energy-water deplete more slowly. Demonstrate this. Compare duration of flow (the time at finish minus time at start) to the duration of flow recorded for the original tube or hose.

   Some students may suggest raising the lower bucket to slow the flow. If you do this, be sure that you premeasure the volume of water in the original container and the volume of water delivered to the lower one as well as record the time. Then you have the data you need to figure whether the rate of flow changed (volume of water delivered/time) regardless of whether or not the total volume of water is delivered.

3. "Can the flow be increased?" Demonstrate this with a larger bore tubing or hose. Again record duration of the flow. Compare results to our rate of use of sources of energy that are not renewable. Some of them, coal especially, could last hundreds of years if we do not increase the current rate of consumption.

Summary

Our history of using more and more fossil fuels per year, especially petroleum, is like increasing the bore of the siphon tube regularly. We are using up resources rapidly. Developing technology for using alternative energy sources and changing patterns of living, working, building, and traveling takes time. Slowing the rate of energy consumption would give us more time to make changes before fossil fuel supplies are unavailable.

A More Quantitative Approach:

If science or math is your specialty, you may want to develop a more mathematical basis for this analogy. Small increases in diameter of the tubing make sizable increases in the rate of flow. This can be used as an analogy to exponential growth, a key concept in environmental education and in economics as well. That is, small increases compounded over time quickly double any given quantity.

For this approach, be sure to use tubing that is comparable in every way except diameter. Flexible, smooth-walled plastic tubing is recommended. It is available from most pet stores, aquarium and scientific supply houses, and some hardware stores and it comes in 1/8", 1/4", 3/8", 1/2", and larger sizes.

Formulae for flow in pipes are complex, with variables of fluid resistance and rough and smooth boundaries. You can approximate differences in flow, however, by carefully timing (with stopwatch or digital watch) the duration required for water flowing from a certain diameter siphon tube to fill a plastic gallon jug or to fill a one liter graduated cylinder.

Some Questions to Investigate:

1. Can you calculate the rate of flow for each size of tubing? Use the formula: $\text{Rate of flow} = \frac{\text{volume delivered}}{\text{time}}$

   Usually a rate per second is practical. To avoid a fraction in the numerator, use some equivalent units smaller than "gallon" and "liter." Keep in mind that one gallon = 4 quarts = 8 pints = 16 cups - 256 Tbsp. = 768 tsp. One liter simply = 1,000 ml.

2. As diameter of the tube is varied, does the rate of flow change arithmetically or geometrically?

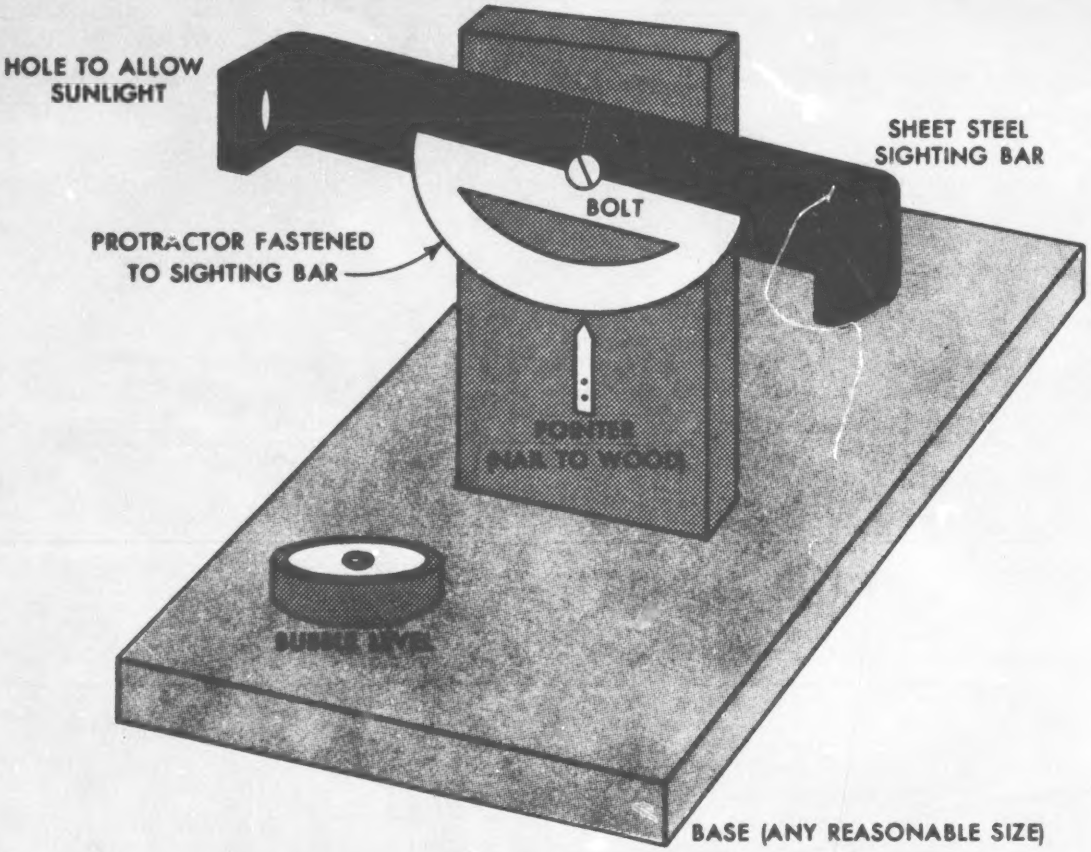
3. Does this change correspond closely to the area of the tube opening or does it correlate better with the circumference of the opening?

4. Can you calculate the total surface area of the tubig in contact with the water? (Surface area of the tube will be circumference x length, or length x diameter x pi).

5. Would there be proportionately more friction potential (between the water and the plastic tube wall) in a larger diameter hose vs. a smaller one?

Solar Clinometer

One critical factor in determining favorable orientation of a stationary solar collector is the altitude of the Sun during the coldest month. The solar clinometer is a simple device that will accurately measure this quantity. It can also be used to measure altitude of the Sun at times of equinox (around March 21 and September 21). Readings close to or on these dates should correspond to latitude of the site where this clinometer is used.


HOLE TO ALLOW SUNLIGHT
SHEET STEEL SIGHTING BAR
BOLT
PROTRACTOR FASTENED TO SIGHTING BAR
POINTER (NAIL TO WOOD)
BUBBLE LEVEL
BASE (ANY REASONABLE SIZE)

This clinometer diagram comes from "Activities: Earth Science," Solar Energy Project by U. S. Department of Energy, 1979. For sale from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

That Spotty Powerplant

Objective:

To learn more about behavior of the SUN, Earth's powerplant in the sky, and to look for patterns of change in its history.

Materials:

Graph paper, pencil
Record of annual sunspot numbers, 1906-1978

Procedure:

Look at the columns of numbers of sunspots for various years. Locate the largest and smallest numbers recorded in this time period. (The numbers are often fractions because they represent averages of those numbers reported by various observers around the world.) These indicate the range of numbers to be included on your graph.

Do the numbers listed increase or decrease over time? Is there a "trend" in the numbers? If yes, how long does the "trend" last?

The answers to these questions may be more obvious if you draw a picture of the numerical relationships. Such a picture is called a graph. Draw boundaries first, a vertical one near the left edge of your paper and a horizontal one near the lower edge. Label the vertical edge "number of sunspots" and put appropriate figures at regular intervals. (Always keep the same distance for a regular increase in numbers.) Then mark the intervals for the years on the horizontal axis. Put a point in the appropriate place for each year's data. Then connect the points.

Now use your graph to make the predictions necessary to answer the following questions:

1. What is the average time between the high points (periods of maximum sunspot activity) on your graph?

2. How many sunspots will there probably be this year?

3. What future years will be best for the next International Quiet Sun Year (time of minimum sunspots)? 1975-76 was such a period in the past.

4. In what year will the next maximum sunspot activity take place?

5. How old is the Sun compared to the length of your sunspot record? Is this sunspot record long enough to be a fair sampling of solar behavior?

ANNUAL SUNSPOT NUMBERS, 1906-1978

Year	Sunspot Number	Year	Sunspot Number	Year	Sunspot Number
1906	53.8	1931	21.2	1955	38.0
1907	62.0	1932	11.1	1956	141.7
1908	48.5	1933	5.7	1957	189.9
1909	43.9	1934	8.7	1958	184.6
1910	18.6	1935	36.1	1959	158.8
1911	5.7	1936	79.7	1960	112.3
1912	3.6	1937	114.4	1961	53.9
1913	1.4	1938	109.6	1962	37.6
1914	9.6	1939	88.8	1963	27.9
1915	47.4	1940	67.8	1964	10.2
1916	57.1	1941	47.5	1965	15.1
1917	103.9	1942	30.6	1966	47.0
1918	80.6	1943	16.3	1967	93.8
1919	63.6	1944	11.0	1968	105.9
1920	37.6	1945	33.2	1969	105.5
1921	26.1	1946	92.6	1970	104.5
1922	14.2	1947	151.5	1971	66.6
1923	5.8	1948	136.2	1972	68.9
1924	16.7	1949	134.7	1973	38.0
1925	44.3	1950	83.9	1974	34.5
1926	63.9	1951	69.3	1975	15.5
1927	69.0	1952	31.5	1976	12.6
1928	77.8	1953	13.9	1977	27.5
1929	65.0	1954	4.4	1978	92.5
1930	35.7			1979	155.4

Data provided by World Data Center A for Solar-Terrestrial Physics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80303.

Teacher's Guide to That Spotty Powerplant in the Sky

Background Information:

The largest single powerplant serving Earth is located 93 million miles away. This nuclear fire called Sun releases energy from nuclear fusion. In solar fusion, nuclei of hydrogen atoms collide, uniting to form helium nuclei and releasing bursts of energy. Deep within the core of this reactor, 564 million tons of hydrogen are converted to 560 tons of helium each second. The remaining 4 million tons per second radiate away as heat and light.

Though these numbers sound very large, solar fusion goes on at a very slow pace compared to other energy conversions. Only because the Sun itself is so large does its energy output become enormous. Pound for pound, the Sun releases much less heat than the human body. How do we know this? It's a matter of arithmetic. The Sun's output of radiant energy, divided by the sun's mass, shows a daily production of two calories per pound (or .002 kilocalories, the food Calorie which is 1000 calories).* By contrast, the human body radiates about 10,000-15,000 calories or 10-15 Calories per pound per day. Maybe you have noticed how quickly a room warms up when people crowd into it for a party.

The Sun's activity is not entirely steady, however. The Sun seems to pulse, like a giant heart (Science News, April 21, 1979). Its granular complexion also has noticeable "spots" that vary in size and number from time to time.

When fog or haze reduce the glare of sunlight, careful observers can often see these large spots on the surface of the Sun. Chinese astronomers recorded sunspots for hundreds of years before telescopes were known in the western world.

Human metabolism converts chemical energy at a rate of .1 kwh hourly or 2.4 kwh daily, the equivalent of 2016 Calories for a person weighing 150-200 lbs.

Sometimes a sunspot lasts for only a few hours, but occasionally one will grow and persist for weeks and months. A relatively small spot measures only a few thousand miles in diameter, roughly the size of Earth. The largest spot on record (1947) expanded to more than seven billion square miles.

Spots are characteristically about 4200° C in their funnel-shaped center, hotter than the hottest blast furnace on Earth. Yet compared to the 5700° C temperature of the surrounding surface of the Sun, spots are cool and appear

---

**The solar statistics are MASS: 1.998 x 10^{30} kg or 4.38 x 10^{30} lbs. HEAT OUTPUT: 3.9 x 10^{23} kw per sec or 93.6 x 10^{23} kwh daily, the equivalent of 8.05 to 10^{30} calories or 8.05 x 10^{27} Calories.*

dark. They are also enormously magnetic and can cause radio and TV transmission difficulties. Lack of sunspots during "quiet Sun" periods has been associated with unusually cold weather.

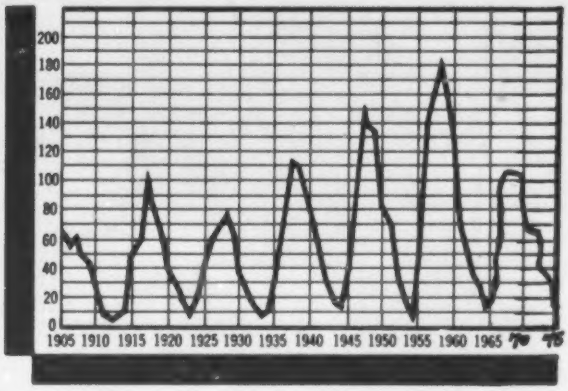
One of the most interesting features of sunspots is the apparent pattern in their appearances and disappearances. In records from the last two centuries, a regularity has been noted. However, 200 years is a very short time compared to the 5 billion years that scientists generally assume is the minimum age of the Sun. No one knows whether modern records describe a brief and temporary phase in solar history or whether this small sample is representative of typical solar behavior.

Four hundred scientists from 17 countries started making a special study of sunspots during "Solar Maximum Year," a project scheduled from August 1979, through February 1981. They hope to be able to improve forecasting of sunspots, solar flares, and other solar turbulence so that their effects on weather and shortwave communications can be anticipated.

Results of Student Activity:

The graphs should look approximately like the one at the right.

Graph showing the sunspot cycles



Question 1 can be answered either from the data directly or from the graph. Intervals between peak activity years, from 1907 on, are 10, 11, 9, 10, 10, and 11 years. The average of these intervals is about 10.1 years.

Question 2 depends on projection of the data on the current year. Answers will vary in magnitude but should be expected to "follow the trend." 1980's guesstimate, for example, can reasonably be expected to be at or near the peak. World Data Center A for Solar-Terrestrial Physics reported (on February 13, 1980) that their calculations suggest a probable value for the sunspot maximum is 160±14.

Question 3 requires checking intervals between "quiet Sun" years (1913, 1923, 1933, 1944, 1954, 1964, 1976). The sequence is 10, 10, 10, 11, 10, 10, 12 ----? Either 10 or 11 are reasonable expectations, so the year quoted would be 1986 or 1987.

Question 4 requires application of the answer to question 1. Either 1979 or 1980 is anticipated to be a maximum. Some students may assume that 1979 was a maximum and project the next one to be 1989 or 1990. Someone from the class may be encouraged to write the World Data Center (address on Sunspot Chart) for the most recent figures.

Question 5 directs attention to Sun's long history (at least 5 billion years) compared to man's very brief recording of it. The sunspot record provided for your students includes 74 years, only .000000015 of Sun's estimated age. If the Sun's duration is compared to the life of a 16-year old student, then this sunspot data is a seven-second episode. One astronomer claims that for a 70 year period from A.D. 1645 to 1715, sunspots were almost totally absent on the surface of the Sun, and the Earth experienced the chill of the "Little Ice Age." John A. Eddy's method of analysis and his conclusions on solar cycles are the subject of "When the Sun Went Strangely Quiet," Science News, vol. 109, March 6, 1976.

Sun Fun

"Gather ye sunbeams while ye may...."

Background:

Fuel is a form of concentrated energy that can be rapidly released. Sunshine comes in slowly and steadily, but it is low-power in its "raw" state. Natural concentration of it (by plants, animals, and geophysical processes) required millions of years. Research scientists are looking for ways to speed this process and to concentrate solar energy by means of human inventions.

In order to collect sufficient solar energy in one location at one time for high-heat processes, concentrations and/or reflectors are needed. One of the experimental ways of generating electricity from sunlight, for example, uses hundreds of mirrored reflectors to beam sunlight onto a boiler, changing its contents to steam that turns a conventional turbine. Historically, curved lenses were known as "burning glasses". Eighteenth century French scientist Lavoisier fused metals by concentrating sunlight through an array of hollow glass lenses and a parabolic reflector.

Objectives:

To expose students to the challenge of directing enough solar energy onto a piece of paper to raise it to kindling temperature;

To develop awareness that there is a cost (materials and know-how) in using "free" sunshine;

To introduce some vocabulary: collecting, focusing, concentrating, power.

Procedure:

On a sunny day, take students outdoors. Provide them with magnifying glasses and ask them to determine how much time is required to ignite a small piece of paper with one. (Place the paper on a sidewalk, a brick, or a glazed tile.)

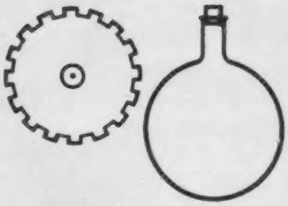
Encourage them to repeat their efforts, using small pieces of flat glass, small pieces of mirror, or eyeglasses. Set a time limit for these trials (ten minutes for each trial is reasonable on a clear day) so that there is class time left for discussion of why some pieces of glass can light a fire and others cannot.

If you have or can borrow a Fresnel lens and holder, you may want to set it up to demonstrate its effectiveness in concentrating solar energy. It can ignite a piece of paper in seconds.

Results:

Most students can ignite the paper with a magnifying glass. Steady hands and patience are required to keep the light beam in the same spot for a few minutes. Eyeglasses may or may not work, depending on their thickness and curvature.

The flat glass will not start a fire. Students will notice that no beam or white spot can be derived from its use. The single mirrors also will not have any noticeable effect. However, it may be possible to ignite paper if a dozen or more students cooperatively reflect light onto a single small piece of paper.



The Sun's Position in the Sky*

Introduction:

The Sun's position in the sky changes. Where is the Sun found in the early morning? At noon? In the afternoon? Does the position change with the seasons as well as the time of day?

This activity will give you a chance to measure the Sun's position and obtain data which is useful in solar energy design. If we are going to use solar energy to heat our homes, then we need to know something about the Sun's position throughout the whole year.

You will construct a very simple device that will help you measure the angle that the Sun's rays make with the ground. You will compare your data with data other members of the class have collected at different times during the year. You will also compare your data with published solar position data.

Objectives:

At the completion of this activity, you should be able to:

Measure the angle that the Sun's rays make with the ground at any time of day.

Use published solar position tables to find the Sun's altitude and azimuth at any given time and location.

Skills You Need:

How to measure angles with a protractor.

How to level a board using a bubble level.

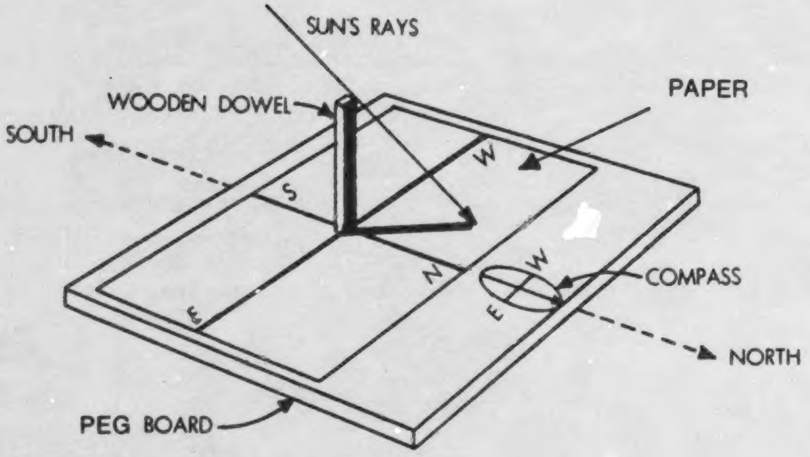
How to read and use a magnetic compass.

How to graph data.

**This activity is one included in the DOE's Solar Energy Project: Activities in Earth Science, 1979, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 061-000-00232-4, $2.00.*

Materials:

A small peg board.
3/8 inch wood dowels.
A magnetic compass.
A bubble level.
A clock or watch.
Paper, pencil, straight edge, and a protractor.



Directions:

1. Locate the mid-point of one long edge of the pegboard and place the dowel into the hole 6 rows in from the mid-point.

2. Place a piece of paper on the board by pushing it down over the dowel.

3. Remove the paper from the board. Draw two lines on the paper, each passing through the center of the hole. One line should be parallel to the long side of the paper; the other should be parallel to the short side of the paper. In other words, these two lines are perpendicular (at right angles or 90°) to each other. Mark the ends N-S, E-W (as shown in the sketch) to show the compass directions to use in lining the board.

86

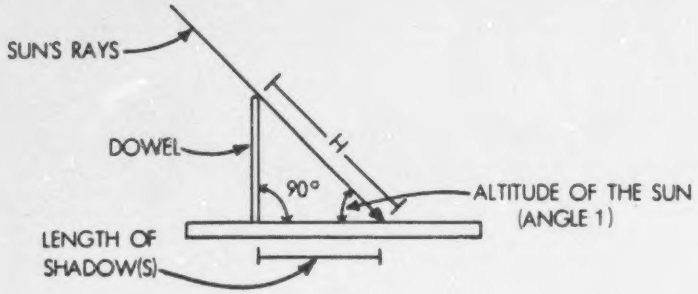
4. Set the board in a horizontal position where it will receive the direct rays of the Sun most of the day. Align the board with the compass as shown in Figure 1. Use the bubble level to check that the board is level. Level it if needed. (Note: Your instructor may suggest aligning the board in a different way).

5. Measure and record the height of the dowel above the top surface of the board.

6. Each 15 minutes draw a line on the paper showing the position of the shadow. Be careful to mark the end of the shadow accurately. Since the positions of the shadows are needed throughout the day, students in all classes will have to make use of each other's data. Record the time and data for each shadow drawn.

7. For each position of the shadow you will want to measure two angles:

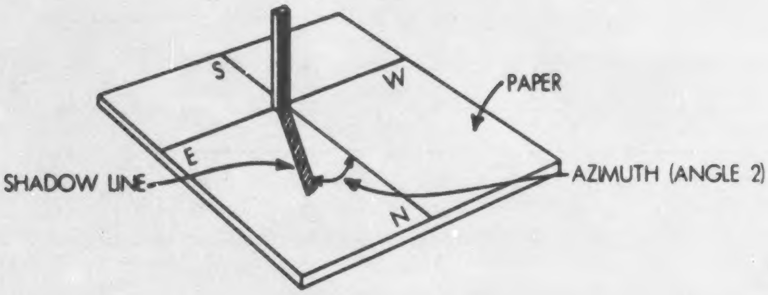
   a. The first is the angle between the shadow(s) on the paper and the slanting side (H) of the triangle as shown in the sketch below. This angle is called the altitude of the Sun.



   On a separate sheet of paper draw a right angle triangle such that the vertical side is equal to the dowel height and the horizontal side is equal to the shadow length. Draw line (H) and measure angle 1. Record: Date, time, and altitude of the sun in degrees on the diagram.

   b. The second angle tells us how much east or west of the N-S line the Sun is. This angle is called the azimuth.

87



Measure angle 2, and record it directly on the apparatus. If the actual position of the Sun is west of the N-S line (in other words, the shadow falls to the east of the N-S line) then the azimuth angle is recorded as so many degrees west. If the Sun is east of the N-S line then the azimuth is recorded as a certain number of degrees east. Example: In the sketch above the azimuth might be approximately 30° W.

8. Prepare a data table for the Sun's position. Include the following information:

Date:		
Time	Sun's Altitude in degrees	Sun's Azimuth in degrees

9. Since the solar energy designer needs this kind of information for the whole year, tables have been carefully prepared by scientists. Compare your data with that in published tables available from the weather bureau. Why are the tables arranged by latitude? What is the approximate latitude where you live?

88

Questions:

1. At what time of day is the Sun's shadow shortest? What does this mean?

2. Are the Sun's shadows longer in summer or winter? Why?

3. It usually seems colder early in the morning than at noon; it is colder in winter than in summer. How are these facts related to what you have just learned?

Extensions:

If you wanted to collect the most energy from the Sun, how would you position a solar collector? Would its position be the same in winter as summer?

Since most solar collectors are fixed (can't be moved) what position would you suggest they be set at? Should they face N, S, E or W? What angle with the ground do you think would be best? (Hint: When are you likely to need the most heat?)

How could you use the position of the Sun in designing the windows in your home so you get the most benefit of the Sun's energy?

What effect does the design of roof eaves or overhang have on the energy received by the windows in your home?

In landscaping your home, how might trees be used to keep your house cooler in summer but warmer in winter? What kind of trees would you use in what position?

Using data on solar position, make a simple outline drawing of a house with windows showing how the Sun's rays would enter at different times of the year. Show how changes in windows, roof overhang, etc. would affect the amount of direct sunlight energy received.

You might want to experiment with cardboard models of a house to show the effect of window size, position, and location as well as roof overhang on the amount of energy received within the interior (inside) of the house.

Teacher's Guide to The Sun's Position in the Sky

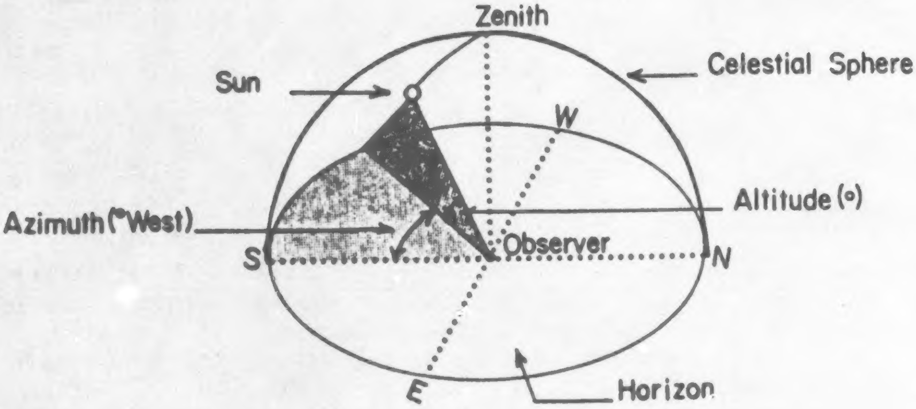
Background Information:

Perhaps the most fundamental information needed by the solar energy experimenter is solar position and intensity data. The apparent position of the Sun changes throughout the day as a result of the Earth's rotation about its axis. The Sun appears to rise each day in a generally eastern direction and sets in a generally western direction. As the Earth revolves about the Sun during the course of the year, the exact path that the Sun appears to take changes. This is a result of the fact that the Earth's rotational axis is tilted 23 1/2° with respect to a line drawn perpendicular to the plane of the Earth's orbit about the Sun. Only twice a year then, around March 21 (the vernal equinox) and September 23 (the autumnal equinox), does the Sun appear to rise directly at the east point and set directly at the west point. The Sun reaches the lowest point (at noon) in the southern sky December 22 (winter solstice) and the highest point June 21 (summer solstice).

Several systems of coordinates are used to describe the position of celestial bodies. One, which is quite similar to the equatorial system of longitude and latitude on Earth, makes use of the "celestial sphere" with star position measured in terms of "right ascension" and declination. Generally, however, the more straightforward horizon system, similar to that used by navigators or surveyors, is used by those working in the solar energy field. The position of the Sun is described in terms of its altitude (angle) and its azimuth (angle).

The altitude of the Sun is determined by measuring the angle between the observer's line of sight to the Sun and the horizon (the horizontal plane of the observer). The azimuth measurement used by solar energy workers is slightly different than that used by surveyors. The azimuth is the angle measured between the N-S line and the projection of the line of sight onto the horizontal plane. The angle is measured between the S horizon point and the projection on the horizontal plane of the line of sight to the Sun. The azimuth will therefore be a measurement in degrees E (in the morning) or of degrees W (in the afternoon). (In the surveyor's system, all measurements of azimuth are made by measuring the angle clockwise from the N horizon point and can have the values from 0° to 360°).

90



In this discussion, the directions referred to are the geographical rather than the magnetic compass directions. Since the north magnetic pole does not correspond with the true or geographical pole, corrections to compass readings must be made to correct for the magnetic declination at any given locality. The magnetic declination is the angle between the direction the compass needle points and true north; values for magnetic declination can be found on local topographical maps or in tables in most physics reference books.

At 12 o'clock noon, Sun time, the Sun would be located somewhere along the imaginary line that passes through the N-S points and your zenith. However, 12 o'clock solar time does not correspond to 12 o'clock standard time. For this reason, the Sun's shadow does not fall exactly along a line running north and south at 12:00 noon (clock time). Correction can be made for local time as follows:

> There are 24 time zones extending around the earth, these extend over 360°. Each time zone covers approximately 15° of longitude (360°   24). This means that 1° of longitude corresponds to a time difference of 4 minutes.
>
> $15° = 1 \text{ hr.} = 60 \text{ minutes therefore, } 1° = \frac{60}{15}\,\frac{\text{minutes}}{\text{degrees}} = 4 \text{ minutes/degree}$

Longitude is measured westward from the prime meridian at Greenwich, England. Therefore, longitudes of 0°, 15°, 30°, 45°, 60°, 75° etc. correspond to the center of each time zone. The center of the Eastern Time Zone is the meridian with a longitude of 75°. Add or subtract 4 minutes to the time for every degree of longitude that you are east or west of the center of your time zone.

Example: Your clock reads 10 o'clock Eastern Standard Time. Your longitude is 80°. This is 5° west of the 75th meridian where it is actually 10 o'clock. Subtract 5 degrees x 4 minutes/degree = 20 minutes. It is 9:40 solar time at your locality. The Sun will not be on your meridian until 10:20 a.m. (clock time). For very precise measurements an additional correction can be applied to correct for the fact that the Sun is sometimes ahead of clock time by a few minutes and other times behind clock time. This correction, known as the "equation of time," can amount to as much as 16 minutes at certain times of the year. Graphs or correction tables can be found in most college astronomy textbooks under "Equation of Time." This variation is caused by the eccentricity of the Earth's orbit and the obliquity of the ecliptic, the annual path of the Sun in the sky.

In this activity, the board must be oriented in some direction. In general, the students appear to be able to handle magnetic north to true-north corrections more readily than those involving solar-time to clock-time. Perhaps the simplest procedure is to have students merely align the boards in a magnetic north-south direction. After all, lot descriptions and building orientations are likely to be done in terms of magnetic compass bearings; but be prepared to tackle the inevitable question, "Why doesn't the shadow lie north-south at 12 o'clock noon?" Most solar position tables are given in terms of solar time and angular measurements from true south; student data will not agree with published data unless these references are used.

Hints on Gathering Materials:

All materials necessary are likely to be readily available.

Peg board stands are common in many classrooms with holes to accept 3/8" dowels (size not critical). Have extra dowels on hand.

Solar insolation data are available from your nearest United States Weather Bureau Office. For Iowans, these are at Des Moines and Mason City, Iowa; Sioux Falls, S.D.; Omaha, Neb.; Moline, Ill.

Suggested Time Allotment:

Two days: Day One: Introduction, set up, initial data. Day Two: Plotting data, comparing results, interpretation.

Periodic collection of additional data during rest of year.

Suggested Approach:

Work in teams of two students.

For continuing data collection, get volunteers from each class to take data on a semi-monthly basis. One person may wish to act as a coordinator of the project.

A permanent set-up might be made outside of the classroom for collection of this additional data. This would minimize set up time and insure consistent orientation of the data sheets. Data should be taken that is based on solar time and true N-S orientation.

Typical Results:

Angular values for altitude and azimuth will vary among students by several degrees depending upon their care in setting up the equipment and aligning the board initially as well as constructing the triangles later.

The students will be amazed at how fast the shadow position changes.

The symmetry of morning and afternoon readings will become apparent.

Student data will agree closely enough with published data to make this meaningful to the students.

Precautions:

AT NO TIME SHOULD THE STUDENTS LOOK DIRECTLY AT THE SUN. This could cause serious injury to their eyes.

Modifications:

Some students may wish to examine sundial theory and construction as an offshoot of this work.

If this activity is carried out with students possessing a knowledge of trigonometry, then the solutions of angles using trigonometric functions instead of measurement by protractor would be appropriate.

Evaluation:

Can the student assemble the apparatus and obtain reasonable data?

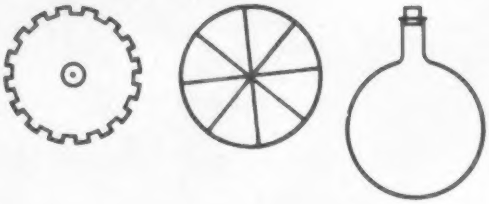
Is this data organized in such a way that it can be used by the rest of the classes?

Can the students interpret and use published solar position data?

References:

Principles of Astronomy, Stanley Wyatt, (Allyn and Bacon, Boston), 1964, p. 545.

Solar Energy Experiments, Thomas Norton, (Rodale Press, Emmans, Penn.), 1977, p. 129.



Up With People Power

Objective:

To relate personal energy expenditures to concepts of work and power.

Concepts:

Energy is the capacity to do work. Work is energy in use to move something. Power is the rate of doing work.

Materials:

Meter sticks
Bathroom scales (metric preferred)
Stopwatch, digital watch, or watch with second hand

Procedure:

1. Locate a stairway in your school or neighborhood where it is possible to climb two consecutive flights or one long flight without interruptions.
2. Taking turns with another student, climb these stairs slowly and steadily while your partner records stopping and starting times.
3. Calculate the total distance climbed by multiplying the height of one step (in centimeters or meters) by the total number of steps. Record this on the chart provided.
4. Measure or calculate each student's mass in kilograms (1 kg = 2.2 lbs. 1 pound = 0.45 kg). Record this on your chart.
5. Climb the stairs again, as fast as possible this time. Have your partner record the time. Then do the same for your partner. (If either of you has a health problem, one can do the leg work for both of you.)
6. The same amount of work was done each time you climbed the stairs, because the amount of material (yourself) and the distance it moved were the same. But the power required was different; power has a time factor in it.

Calculate the power required each time you climbed the stairs.

$$\text{Power} = \frac{\text{mass (kg) x distance (m)}}{\text{time (sec.)}}$$

$$\text{Example: } \frac{\text{65 kg x 6 m}}{\text{10 sec.}} = \frac{\text{390 kgm}}{\text{10 sec.}} = \text{39 kgm/sec. or 39 units of power}$$

Use your figures now:

1. Climbing stairs slowly . . .

2. Climbing stairs rapidly . . .

Student Worksheet

Name ______________________________

UP WITH PEOPLE POWER

	Climbing Stairs	
Measurements & Calculations	slowly	rapidly
3. a. height of one step (m)		
b. number of steps climbed		
c. total distance climbed (m)		
4. mass of student (kg)		
2.& 5. time required (sec)		
6. power required		

Use the back of this sheet for calculations if necessary. Put answers on the chart.

Compare the results (numbers) on the chart for climbing rapidly vs. climbing slowly. What do they tell you about energy, work and power?

Did you see or feel any difference between climbing slowly and climbing rapidly that does not show up on your chart?

Waxing Hot

Objective:

To compare the heat-storing ability of some common solids.

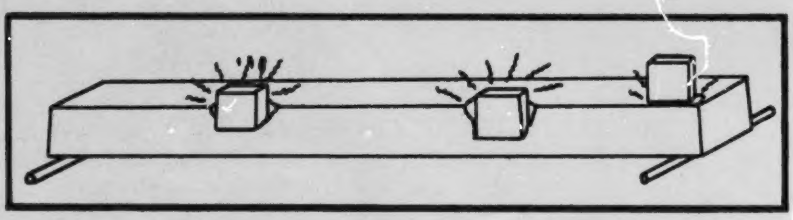
Materials:

1/2" cubes of wood, plastic, steel, aluminum[1];
    or glass, plastic, wood, and metal marbles[1];
    or assorted washers: fiber, neoprene, fiberglass, metals, from hardware store;
    or beads made of different materials: metals, wood, glass, papier-maché, plastic, stone.)
One pound box of canning paraffin (comes in 4-5 slabs, each about 1 cm thick)
Small blocks of wood or extra pencils to support paraffin slabs
Small oven for heating materials
Asbestos gloves

Procedure:

Heat the assorted objects in the oven at 175° C (about 350° F) for 15 minutes. Set a slab of paraffin on small blocks or pencils so that it is not touching the table top.

When the objects are hot, pick them out quickly, using asbestos glove, and set them on the paraffin to melt their way through.



---

[1] *Available in some science kits and toy or game stores, or by ordering from American Science and Engineering Company, 75 Cambridge Parkway, Cambridge, Mass., 02142.*

Expected Results:

Iron and brass objects are likely to sink in deepest; glass and plastic will melt in little; and wood only softens enough surface to keep it firmly attached to the wax. If you started with objects of equal volume, like cubes or marbles, the different heights of various ones (above the paraffin) are evidence of differential amounts of heat held by the assorted materials.

If you have a balance scale available, this demonstration can be done using comparable weights instead of comparable volumes of material. Advanced students may try to go further and relate density to heat-storing capacity . . . but there is no correlation. The "specific heat" that one gram of any particular material requires to raise its temperature 1°C is as individual as a fingerprint, different for every substance.

Quantitative Extension:

Using styrofoam cups, thermometers, and 100 cc of water in each cup, record the temperature of the water. Then add hot objects of known weight into the water. Record the temperature every minute for 10 minutes.

1. Calculate how many calories of heat were released to the water by various materials.

   100 cc H_2O x ____________________ = _______________calories
   temp. change, °C

2. Calculate the specific heat of each material by relating the calories released to the weight of the material and initial temperature difference between the water and the heated object.

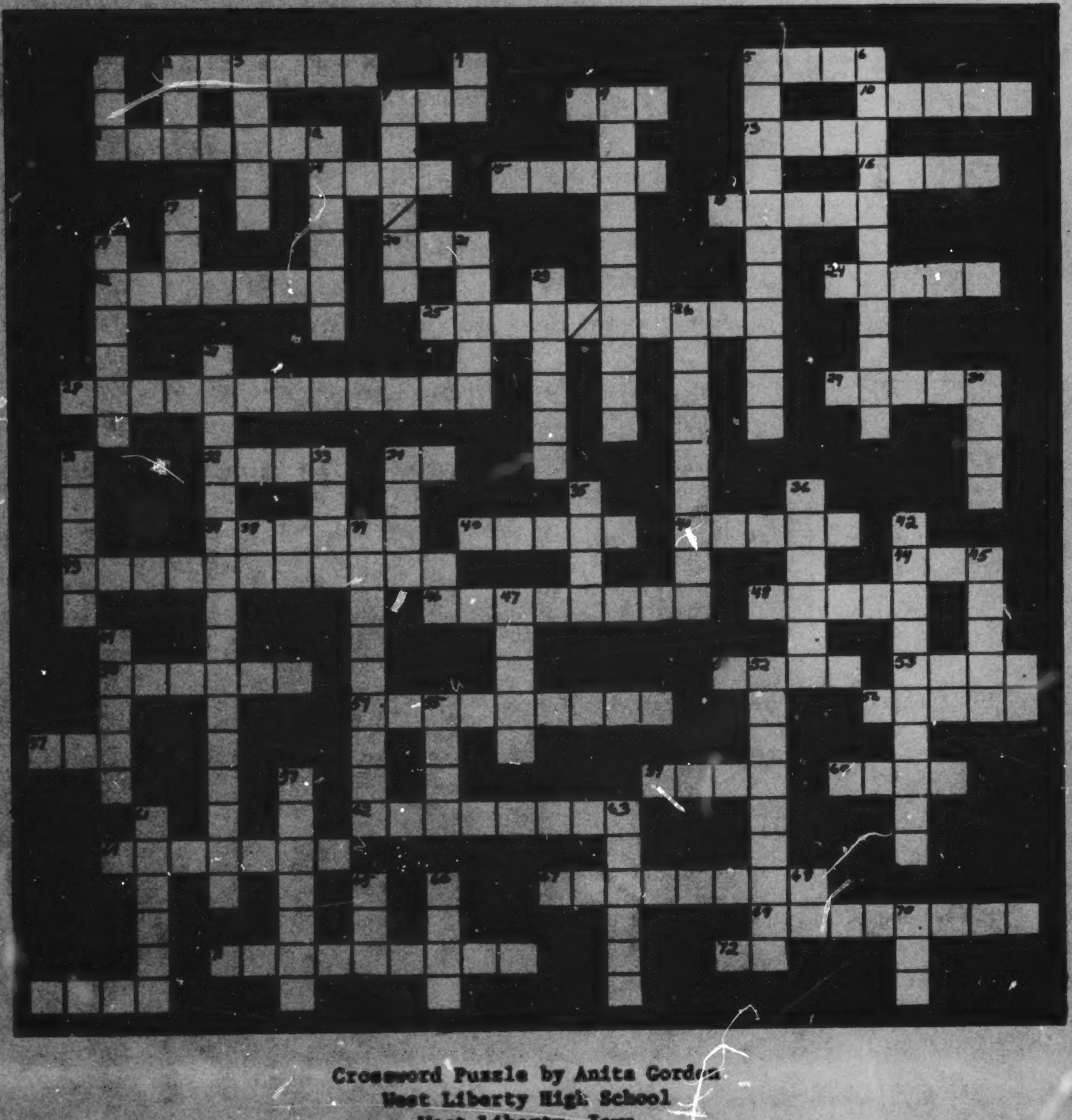
   Example: A steel cube weighing 30 g was heated from 25°C to 175°C and then dropped into 100 cc of water at 25° C. Over a five-minute period, the water temperature rose to 29°C. What is the specific heat of the cube?

   a. Temperature change of cube is 175° - 25° = 150°C
   b. Weight of cube is 30 gm.
   c. Calories released to water is (29°-25°) x 100 = 400 cal.

   Specific heat is cal/gm per degree or 400/30/150 ≅ .09

   (This is less than the 0.105 cal/gm degree usually stated in tables, but losses can easily be accounted for in the transfer from oven to water, and the lack of a sophisticated calorimeter with a tight and insulated lid.)

Words About Energy - I



Crossword Puzzle by Anita Gordon
West Liberty High School
West Liberty, Iowa

Energy Crossword Puzzle
by Anita Gorden*

Background:

This puzzle was designed for high school students investigating energy. Terms used in the crossword puzzle are basic energy concepts, in order for this learning activity to be applicable to energy units in housing, clothing, foods, personal care, and family living.

Intended Use:

This puzzle can be used as a teaching aid, unit review, or as a self-instructional learning experience.

Objective:

To familiarize the student with key terms and facts related to energy.

Directions:

ACROSS:

2. A nuclear reaction involving the combination of smaller particles into larger ones with the release of energy.

5. A residue of coal used for fuel.

7. Our source of solar energy.

8. The quantity of heat required to raise the temperature of one pound of water one degree F.

10. Identifies natural or synthetic fabric.

11. Less than one percent of the atoms of this element will produce energy in a nuclear reactor.

13. Not any.

14. Basic building block of all matter.

15. A means of payment for your utility bill.

16. The outlay or expenditure for energy.

**This activity was written at a DOE-sponsored workshop directed by Ella Jedlicka at U.N.I., Cedar Falls, Iowa, June, 1978.*

18. Official examination of building for heat usage.

20. This energy resource is formed from the fossils of ancient plants and animals.

22. The amount of force employed to move a quantity of electricity.

24. Radiant energy which an observer can see.

25. This type of bulb gives more light per watt of electricity than others.

28. The energy produced by splitting atoms in a nuclear reactor (2 words).

29. Insulation in the _______ can cut energy loss through the roof.

32. Designed to prevent heat loss (clue: _________ underwear).

37. A demand for repetition.

40. Series of events that recur regularly.

41. A large international petroleum company.

43. The external conditions and influences affecting your life and development.

44. Recent; fresh.

46. A unit that measures the rate at which energy is produced or used.

48. Perennial plants that are a source of a fuel.

50. American demand for this resource has doubled repeatedly every 10-18 years.

51. A substance used to produce heat energy.

52. After the expected time.

54. Emission and propagation of energy through space.

56. A material essential to every living thing.

57. Department of Energy.

59. A solid fuel, mostly carbon.

60. Making only one _______ or less to the grocery store each week saves energy.

62. Source of warmth and light.

64. An enclosed structure in which heat is produced.

67. ___________ consumption is expected to triple in the next twenty years if it follows past trends.

69. Prudent; thrifty.

71. An electric current that reverses its direction at regularly recurring intervals.

72. The largest energy consumer in the world.

73. Extending for a considerable distance.

DOWN:

1. This puzzle contains words ______ should know concerning energy.

2. Federal Housing Administration.

3. One effective energy conservation measure for mobile homes is building an enclosure called a ______ to keep wind from sweeping under the floor. (Hint: article of clothing for women).

4. When the television is _______ and no one is watching, energy is being wasted.

5. Your use of economic goods to supply your wants and needs.

6. This is a very convenient power supply.

7. There is no electrical (7 letters), so it's made to order when you need it.

9. A device for regulating room temperature.

12. Anything which is solid, liquid, or gas.

17. A liquid fuel formed from the fossils of animals and plants.

19. The measure of resistance to heat flow; used to rate insulation.

21. Radiation energy from the Sun.

23. Coal, oil, and natural gas are examples of _______ fuels because they originate from geologic deposits of ancient plant and animal life.

26. An appliance is __________ if it has a high ratio of useful work performed in relation to the amount of energy it uses.

27. Reduces drafts by making sure that all doors and windows fit their frames snugly.

30. When washing clothes, use __________ water to conserve energy.

31. The time rate at which work is done.

33. A southfacing _________ receives maximum Sun in the winter.

34. Hearty approval.

35. Circulate; move freely.

36. A generative force.

38. If present trends continue, will the American energy demand remain constant until the year 2000?

39. Natural gas, coal, oil, and wood are natural _________.

42. Substances that can slow down the flow of heat and sound in your home.

45. Energy that escapes as heat without doing any work.

47. Nearby (clue: your _______ extension office is a source of energy information).

49. An instrument for measuring the amount of fuel used.

52. Heat, power, water, telephone.

55. One of nature's best insulators comes from birds.

58. Large group of people enjoying available energy.

61. Exchanging money for energy.

63. Able to do work.

65. Energy Efficiency Ratio.

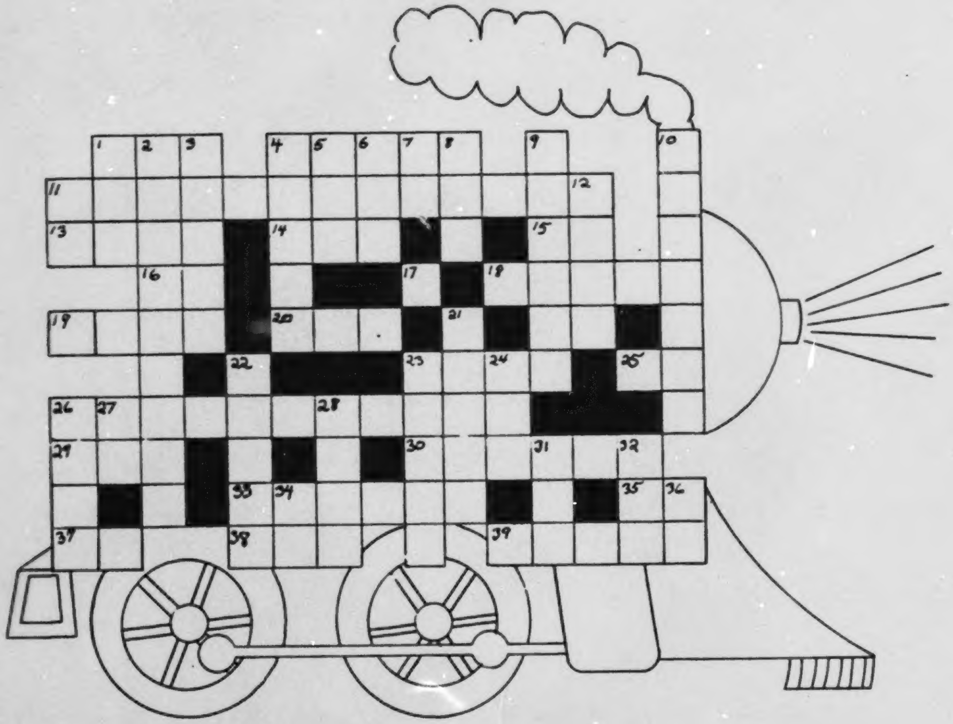
66. Highest portion of the daily energy load.

70. The way to leave lights in an empty room.

Gorden Energy Puzzle Key

```
    Y   F U S I O N     O               C O K E
    O   H   K       S U N     B T U     O     L A B E L
    U R A N I U M   T           H       N O N E
            R   A T O M   M O N E Y     S     C O S T
        O   T   T   R/A         R     A U D I T
    R   I       T   G A S       M       M     R
    V O L T A G E   E   O   F   O       P   L I G H T
    A           R     F L U O R/E S C E N T     C
    L     W             A   S   T   F   I     I
  N U C L E A R P O W E R   S   A   F   O   A T T I C
    E     A                 I   T   I   N     Y     O
  P       T H E R M A L     L       C               L
  O       H     O   M         F     I     S         D
  W       E N C O R E   C Y C L E   E X X O N   I
  E N V I R O N M E N T       O     N     U     N E W
  R       S       S   K I L O W A T T   T R E E S   A
    M     T       O       O               C     U   S
    E N E R G Y   U       C           F U E L   L A T E
    T     I       R A D I A T I O N     T     W A T E R
  DOE     P       C   O   L             I       T
    R     P   S   E   W           C O A L   T R I P
      B   I   O   S U N S H I N E       I       O
    F U R N A C E               N       T       N
      Y   G   I   E   P     E L E C T R I C
      I       E   E   E         R       E C O N O M I C
      N   A L T E R N A T E     G     U S       F
   LONG       Y       K         Y               F
```

Words About Energy - II


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

The Energy Express(ion)

Directions:

Put a little energy into expanding your vocabulary. Then you'll be able to keep on the track and steam ahead by observing these signals:

ACROSS:

1. To choose freely.

4. What a kite or glider will do in a good wind.

11. Moving because of the application of heat (adj.).

13. Exhausted, run out, hollow (phonetic spelling).

14. The side sheltered from wind.

15. Sometimes this is an energy-saving response.

16. Worker providing medical services at low-energy cost (abbr.)

17. Initial of a scientist who devised a centigrade thermometer.

18. How to survive in challenging times.

19. Stored solar energy resource most used by less developed countries.

20. Roentgen equivalent man, (abbr.) unit of biological dose of radiation.

23. Mode of transportation that is an energy-efficient freight mover.

25. The most basic energy-producing business (abbr.).

26. Power for small motors.

29. Engineers' measure of heat; the amount of heat required to raise one pound of water 1° F.

30. Metric unit of time; fraction of a minute.

33. Person who lives in the countryside, known as a back-to-the ____________.

35. Domesticated animal that is a major power source in some developing countries.

37. Warm prevailing wind.

38. Unit of weight (British system) (abbr.).

39. Energy-saving devices; furniture usually found wherever people live or work.

DOWN:

1. Unit of electrical resistance.

2. Naturally occurring mixture of crude oils.

3. Turn toward a particular direction or course; as in, "Car dealers report that the buyers' ____________ is toward small cars."

4. Renewable energy on which all living things depend.

5. Kind of poem. Shelley wrote one ". . . to the West Wind."

6. Intelligent response to calls for conservation; a vote in favor of energy saving.

7. Symbol of radon gas, a by-product of radioactivity.

8. Useful tool for processing man's oldest fuel.

9. Invisible energy source that can provide electricity or hot water in some locations.

10. Electrical potential expressed in volts.

11. Thermal energy (abbr.).

12. Solid, non-renewable, fossil fuel.

21. Very heat-absorbent liquid.

22. Equipment for separating fresh water from salt or alcohol from grain; may be directly solar-powered.

23. What warmer fluids have always done.

24. International Yodeling Contest (abbr.), a low-energy production of musical entertainment.

26. What the tide does daily.

27. The kind of energy eye-witnesses depend on (abbr.).

28. Charged particles involved in chemical and electrical energy transfers.

31. Number of times a human being can completely stop using energy.

32. Department of Transportation.

34. "Absolute" (abbr.).

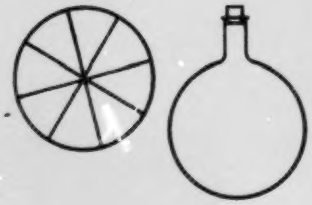
36. Unknown quantities.

Teacher's Guide to Words About Energy - II

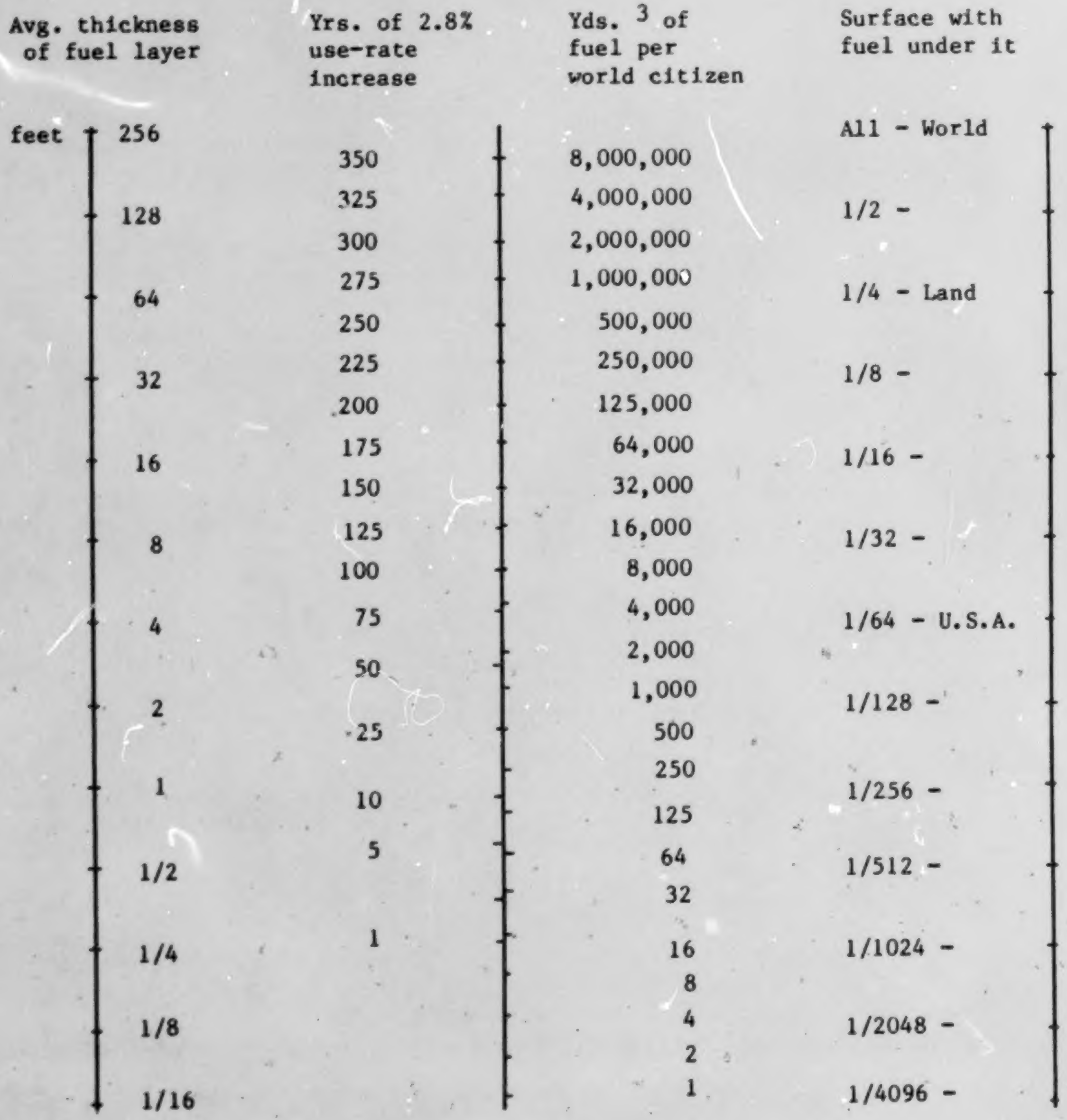
Answer Key

```
     1 2 3   4 5 6 7 8   9     10
     O P T   S O A R S   W     V
11 T H E R M O D Y N A M I C   O
13 E M T E   L E E   W   N O   L
       R N   A     C   A D A P T
19 W O O D   R E M   W     L   A
       L   S       R A I L   A G
26 E L E C T R I C I T Y       E
29 B T U   I   O   S E C O N D
   B   M   L A N D E R   N   O X
37 S W     L B S   N   S E A T S
```

108



Fuel Supply and Demand Relationships on Planet Earth



Nomogram by Dr. Paul A. Smith
Coe College, Cedar Rapids, IA

Teacher's Guide to Fuel Supply and Demand: A Nomogram

A nomogram is a kind of chart that can be used to graphically describe three related quantities. To use the one supplied here, have students decide how much of Earth's surface is likely to have fossil fuel under it (right hand column) and about how thick, on the average, these deposits may be (left hand column). As a point of comparison, the average coal seam is 3-6 feet thick. Using the nomogram, draw a straight line between these points. Read on the middle axis the number of years that the growing demand can be met.

As examples, if one assumes that all land areas (1/4 of the Earth's surface) have fuel under them, and that the deposits average 1 ft. thickness, then the line crosses the middle axis around 125 years. That is how long the fuel would last under the assumption noted in the next paragraph. Or if one estimates that only one square mile per thousand has fuel under it, but that such deposits are 16 feet thick, then the intersection point is ∽ 35 years; if deposits are 32 feet thick, they may last ∽ 50 years.

In constructing this nomogram, Dr. Paul Smith assumed a world population of 4 billion people that would adopt the traditional American consumption pattern of 2.8% annual increase in total energy use (that is, doubling consumption every 25 years), starting at 13.6 cubic yards/person/year of fossil fuels or ∽ 500 yds^3 per person the first 25 years.

This simplified graphic calculation does not account for growing population, another critical variable. There are already more than 4 billion people in the world and their numbers are increasing. Fulfilling expectations of American-style energy consumption will exhaust fossil fuel reserves much faster than the nomogram would suggest.

Use of the nomogram should help students realize that energy crises are likely to be with us on a long-range basis if we continue to depend heavily on mined, non-renewable resources. The hundred-plus years of American energy use and industrial expansion is an example of exponential growth that cannot last indefinitely on a space-ship Earth.

Dr. Paul Smith predicts, "So long as our rate of consuming energy continues to grow there is no way that technology can meet the long-range demands for energy nor deal with problems of thermal pollution. Energy consumption will stop growing and so will economic activities that depend upon increasing energy consumption."

110

Modeling Exponential Growth

by John W. Christensen*

Background:

Probably the most significant cause of the energy/environmental predicament is the phenomenon of exponential growth. Over the past few decades, population, nonrenewable resource consumption, food production, industrial output and pollution generation have all been increasing exponentially. To understand the energy and environmental crises, one must understand exponential growth. This activity is designed to give that understanding. It is built around the population problem, but can be applied to automobile production and disposal, electrical generating plant construction and demolition, etc.

Purposes:

To use dice to model exponential growth.

To change the variables and attempt to slow down and halt exponential growth.

Procedure:

In this activity you will use dice or colored wooden cubes to model population growth. Each die or cube represents a person. Each throw represents a year. The directions are written assuming you are using dice. If you use wooden cubes, make the substitutions shown below.

event	dice	cubes
birth	3 or 6	white, red
death	1	black

A "3" or a "6" represents the birth of a child, so each time one of them comes up, add a die to the population. If a "1" comes up, a death has occurred, so remove it from the population. Hence you are modeling a situation where the birth rate is twice the death rate. You also have a net population growth rate of 1/6 or about 17%.

**Reprinted with permission of John W. Christensen, Energy/Environment Education Project, Cherry Creek High School, Englewood, CO 80111.*

PART A: Unrestricted Exponential Growth (UEG)

Put six ordinary dice into a container (Adam, Eve, Cain, Abel, Sally, and Alice). Shake the container and dump the contents out onto a smooth, hard floor. Remove and count all the 1's that appear. Record the number of deaths on the chart for Part A. Count up all the 3's and 6's that appear. Since they correspond to births, add a die for each of them. Then fill in the required information in Chart A. Repeat this procedure until the total population exceeds 500 people.

PART B: The Effect of Instituting a Limited Birth Control Program (LBC):

Return to the year where your population first exceeded 100 people. Place that many dice into the container; but now introduce a limited birth control program. This will be modeled by having a "3" and every other "6" represent a birth. The remaining half of the 6's represent couples who are on contraceptives, so a birth has been prevented. If an odd number of 6's comes up, round-off in favor of a birth half of the time, and in favor of a prevented birth for the other half of the cases. Model this situation from where you start to the year 30, using Chart B. You have essentially cut the population growth rate from 17% to 8%.

PART C: The Zero Population Growth Plan (ZPG):

Again return to the year where your population first exceeded 100 people. Place that many dice into the container. But now introduce a large scale birth control program. This will be modeled by having all the 6's represent women using effective birth control techniques or women married to men using effective birth control techniques. Hence, a "1" represents a death, a "3" represents a birth, and a "6" represents a prevented birth. Model this situation from where you start to the year 30, using Chart C.

PART D: World Population Trends:

The following is a listing of estimates of world population (in millions), 1650 to 1978. Figures such as these are compiled by the United Nations and are published in most almanacs. Plot a graph of world population vs. time (1650 to 1978).

Population Estimates (millions)

1650 = 470
1750 = 694
1850 = 1,091
1900 = 1,571
1930 = 2,070
1940 = 2,295
1950 = 2,517
1960 = 3,003
1970 = 3,632
1978 = 4,219 (est.)

PART E: The Nature of Exponential Growth:

Examine the following four facts about exponential growth and relate them to your graphs.

1. Exponential growth occurs whenever the rate of growth is directly proportional to the quantity of material present.

$$\frac{\Delta N}{\Delta t} \propto N$$

2. A quantity exhibits exponential growth when it increases by a constant percentage of the whole in a constant time period (like compound interest on a savings account).

$$\frac{\Delta N}{N} \propto \Delta\,\text{[illegible]}$$

3. Exponential growth is deceptive, because it starts out very slowly, but it is capable of generating immense numbers very quickly.

4. It is useful to think of exponential growth in terms of doubling time.

$$\text{Doubling Time (in years)} \cong \frac{70}{\text{\% annual growth rate}}$$

The Characteristics of the Exponential Generation (1974):

Quantity	Annual Growth Rate (%)	Doubling Time (in years)
World Human Population	2.1	33
World Oil & Gas Consumption	7	10
World Industrial Output	7	10
World Food Production	1	70
Electric Power Gen. (U.S.)	9.25	7.6

Data:

Chart A: Unrestricted Exponential Growth (UEG)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice Population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
20				
30				

Data:

Chart B: The Effect of Instituting a Limited Birth Control Program (LBC)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice Population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0	REMINDER:	Begin with the year your popultion first exceeded 100		
2		people.		
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
20				
30				

Data:

Chart C: The Zero Population Growth Plan (ZPG)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0	REMINDER:	Begin with the year your population first exceeded 100		
1		people.		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
20				
30				

Graphs:

PART A: Unrestricted Exponential Growth (UEG):
Use your data to plot graphs of:

1. Population vs. Time (years)
    a. plot first on ordinary paper.
    b. plot again on semi-log paper.
2. Population Growth Rate vs. Time (years)
3. Population Growth Rate vs. Population

Note: If you are confused about which graphs to plot, see the graphing summary at the end of this section.

PART B: The Effect of Instituting a Limited Birth Control Program (LBC):
Use your new data to plot graphs of:

1. Population vs. Time, beginning LBC to year 30 (ordinary graph)
2. Population vs. Time, beginning of LBC to year 30 (semi-log graph)

Plot these on the same graphs as in Part A, but use a different color.

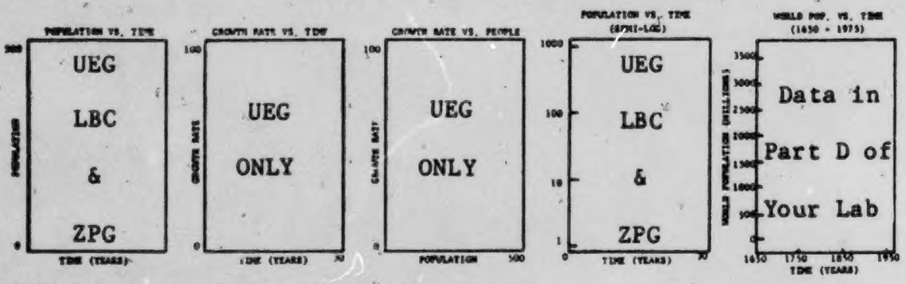
PART C: The Zero Population Growth Plan (ZPG):
Use your data to plot graphs of:

1. Population vs. Time, beginning of ZPG to year 30 (ordinary graph)
2. Population vs. Time, beginning of ZPG to year 30 (semi-log graph)

Plot these on the same graphs as in Part A, but use a different color.

PART D: World Population Trends:
Plot a graph of World Population vs. Time (1650 to 1978).

The following is a summary of the graphs that are to be plotted for this lab:


POPULATION VS. TIME
500
POPULATION
0
UEG
LBC
&
ZPG
TIME (YEARS)
GROWTH RATE VS. TIME
100
GROWTH RATE
0
UEG
ONLY
TIME (YEARS)
30
GROWTH RATE VS. PEOPLE
100
GROWTH RATE
0
UEG
ONLY
POPULATION
500
POPULATION VS. TIME
(SEMI-LOG)
1000
100
10
1
0
UEG
LBC
&
ZPG
TIME (YEARS)
30
WORLD POP. VS. TIME
(1650 - 1975)
3500
3000
2500
2000
1500
1000
500
0
WORLD POPULATION (MILLIONS)
Data in
Part D of
Your Lab
1650
1750
1850
1950
TIME (YEARS)

Where: UEG = unrestricted exponential growth
LBC = limited birth control
ZPG = zero population growth

Write one conclusion for each graph.

Teacher's Guide to Modeling Exponential Growth

Discussion of Activity:

There is a connection between exponential growth and all of our energy/environmental crises. This activity should precede all discussion of exponential growth, population, consumption patterns and pollution generation.

In Part A, it takes about 20-25 minutes to build the population from 6 to 100 and only about 5 minutes to build it from 100 to 500, an important observation of quantities growing exponentially.

The activity is best accomplished in groups of six to eight students gathered around a table. Dividing up the labor saves a great deal of time and is a great exercise in group cooperation.

Materials:

Provide each table with a large can of 300 dice (or cubes). When the population grows beyond that, either roll twice or double your results. Most choose to double their results. For a class of 30 students, use four groups. Hence you need 1,200 dice. Purchase 1,400 to make up for losses and petty thievery.

Dice may be purchased at most variety stores. Painted wooden cubes work just as well and have several advantages over the dice:

1. They cost less.
2. Colors can be separated faster than numbers.
3. They are less likely to be stolen--especially if they are only painted on three sides.

Cut the dice from either 3/4" birch or maple--they soak up less paint and don't easily chip. From a board 3/4" x 2 ft. x 7.5 ft. you can cut approximately 1400 dice (allowing for the width of the table saw blade).

Before cutting, spray paint the board red on one side and black on the other. Then cut your cubes. Place all the cubes on a large sheet of paper unpainted side up and close together (no spaces between the cubes). Spray paint a third side white.

A source of ready-made hardwood cubes (plain ones - the red and white faces must be painted on) is Delta Education, Inc., Box M, Nashua, NH 03061, toll-free phone 1-800-258-1302. Their 1980 catalogue offers item CUB 001 (refill from Ice Cube Kit) a wooden cube set including 60 cubes 1 cm x 1 cm x 1 cm and 3 cubes 1/2" x 1/2" x 1/2" for $1.95 net to schools (per set). Shipping charges will be added to the invoice, f.o.b. Nashua, NH

BASIC UNIT PRICE~$.03

Larger hardwood cubes, 2 cm x 2 cm x 2 cm, are available in sets of 100 (Item 36620) from Creative Publications, 3977 East Bayshore Road, P.O. Box 10328, Palo Alto, CA 94303, phone 1-415-968-3977. Each set of 100 plain cubes is listed at $6.25 in their 1980 catalogue.

BASIC UNIT PRICE ∽ $.0625

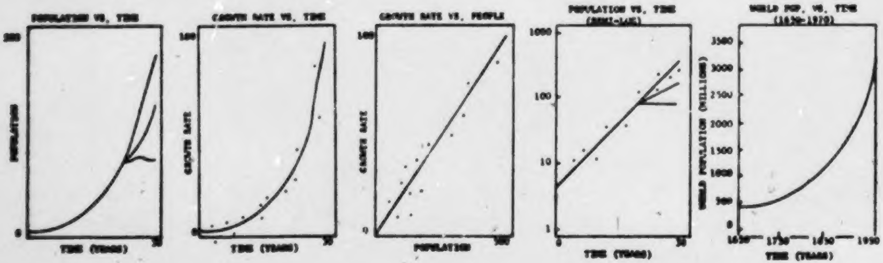
Game and toy stores sometimes sell dice in quantities, at a discount. For example, try Thinkers Emporium, 423 Brady Street, Davenport, IA 52803, phone 1-319-323-7117. In April 1980, their price to teachers for a gross (144) of quality dice, each 5/8" x 5/8" x 5/8", was $16.50. these require no further preparation or coloring. Mail order postage fee is an additional $1.50.

BASIC UNIT PRICE ∽ $.1150

You will need graph paper. This can either be purchased or crudely drawn out and duplicated.

Expected Results:

The sketches below represent typical results:



One problem some students have is with drawing the best line or smooth curve through their data in the case of Growth Rate vs. Time and Growth Rate vs. Population. A graphing review prior to this activity may be helpful.

If time permits, have some students plot a World Population vs. Time graph on semi-log paper, or at least show a plot of this in class. This will help answer the question: Is the rate of world population increase declining?

About one group in forty will start with so many deaths in their first few throws that their population never does increase. You may want to use their data as an example of a plague. If you don't wish to take the time to make this point, have the group begin again.

Sample Conclusions:

1. Population vs. Time

When population grows exponentially and unchecked, it grows slowly when the population is small and then rapidly increases once a significant population base is established.

The limited birth control program slows the overall growth; but since it is still exponential, it can get out of hand if given enough time.

Only when the birth rate equals the death rate is the population growth checked.

2. Growth Rate vs. Time

As the population increases, so does the growth rate. It appears that the growth rate also increases exponentially with time.

3. Growth Rate vs. Population

Averaging out the randomness which is very pronounced when one deals with small numbers of objects, one can see that the best graph is a straight line which passes through the origin.

Hence: Growth Rate $\propto$ Population

4. Exponential growth is indicated by a straight line on semi-log paper. This can serve as a test for exponential growth. The limited birth control program reduces growth, but the growth is still exponential. The ZPG plan stops expoential growth.

5. World Population vs. Time (1650-1978).

This graph looks very similar to the one obtained for unrestricted exponential growth. World population increases slowly from 1650 to 1900, when technology and medicine were relatively undeveloped. However, after 1900, the curve shoots up rapidly. Now, world population increases more in a few decades than it did in a few centuries before 1900.

Discussion:

Discuss the graphs and the conclusions for each one. What you do from there depends upon your class, your priorities and the attitudes prevalent in your area. It is easy to say that exponential growth can be stopped by equating the birth rate to the death rate. How this is actually accomplished is another story altogether.

Planet Earth

Some Measured Limits

Introduction:

There are many conflicting opinions on how long our energy supplies may last. Some experts warn that the end of fossil fuels is already in sight--that is, within 20 years. Others are confident that there are nearly unlimited supplies, that "All we have to do is to hunt for them more aggressively." Some put the blame on legislation designed to restrict discharges into air and water. They assert, "If environmental restrictions were eased, we could use our energy more efficiently and make supplies last much longer."

Who is right? Doesn't anyone have facts that will tell us whether energy shortages are real? Maybe the whole thing is a plot by people who have political or economic motives for swaying public opinion.

In order to come to grips with the questionable basis of many energy-related statements appearing in the popular media, every citizen needs to know that:

1. All of Earth's resources are finite or limited in supply.

2. How quickly we use these resources is the prime factor in determining how long the supplies last.

3. Today's priorities and choices affect tomorrow's prospects.

None of these concepts are obvious on the basis of daily experience in our wealthy country. But they are so important to understanding of energy-related concerns that the effort to help students grasp these concepts must be made. The following group of activities centers on each of these ideas in turn.

Objective:

To familiarize students with the physical limits to fuel supplies inside planet Earth.

Method:

Provide each student with a copy of the chart, "Planet Earth: Some Measured Limits"; or project it on the overhead projector; or give students only the basic information (radius, deepest borehole) and let them derive others (circumference, volume, surface area).

Then, as a class, start deciding limits to the storage area for underground fuels.

1. Imagine Earth itself as one big oil tank (or tanker, if Spaceship Earth is a familiar metaphor). If Earth's "hold" were totally empty of rocks, oceans, metallic ores, magma, etc., how much fuel (maximum) could it contain?

   Most students can visualize this analogy. Having a globe or a basketball on hand helps, however. Figures to develop this comparison are included in a separate section, SUPER-TANKER EARTH. Use these numbers as you choose, either as a "given" or as a guide to simple calculations you can do with your class.

2. Start returning to reality. There is no evidence that Earth is hollow except for a few very tiny blisters we call "caves" or "salt mines." On the contrary, only a compact planet with increasingly dense materials as its core would behave as Earth does. Besides, Earth's average density is 5.5 (that is, five and one-half times as heavy as water, volume for volume) while the average density of most surface rocks is 3.0; coal's density is usually < 2.0; water is 1.0; natural gas is < 0.001.

   Another consideration is that limitations in methods, materials and costs restrict the depths people can reach by drilling. So far, the deepest borehold completed penetrates only six miles below the Earth's surface. So we must confine our search to the "outer skin" of Earth.

   How large is that "skin"? Either use the figures on the accompanying chart or involve the class in calculating the surface area of a sphere with a diameter of 8,000 mi or 12,800 km.

   Surface area $= \pi d^2$ So, using rounded figures,

   $$A = 3.1416 \times 8{,}000 \times 8{,}000 = 2.01 \times 10^8 \text{ mi.}^2$$
   $$\text{or, } A = 3.1416 \times 12{,}800 \times 12{,}800 = 5.15 \times 10^8 \text{ km}^2$$

   Using more exact figures,

   $$A = 3.1416 \times 7{,}926 \times 7{,}926 = 1.97 \times 10^8 \text{ mi.}^2$$
   $$A = 3.1416 \times 12{,}756 \times 12{,}756 = 5.11 \times 10^8 \text{ km}^2$$

   These results show the maximum surface to be explored.

3. Now, how much of that surface area is likely to have fuel under it? There is room for debate here.

   a. Consider that most exploration to date has been on land. Some drilling rigs are, however, tapping continental shelves including the North Sea. (Newer maps of the ocean floors show this area as supra-continental water, not true ocean.) Using World Book Encyclopedia figures provided, proportion of land areas to total surface area of the world is:

$$\frac{57.28 \times 10^6}{196 \times 10^6} \times 100\% = 29.1\%$$

If all continental shelves are added in, this "continental area" may be as much as 35%. The remaining deep oceans, or 65% of the surface area, can be excluded as having no fossil fuel potential. There is no geological evidence to date of reserves there.

b. Of the percent of surface area that possibly could have fuel under it (figure chosen in a.), how much (at most and at least) is likely to have fuel under it? Have the class vote on an upper and a lower limit. You may also want to remind students of the assumption that coal, petroleum and natural gas are all remains of luxuriant former life.

Is it reasonable to assume that all continental areas were densely populated with plants or animals and that all areas experienced the same conditions for burial and differential decomposition of this organic material?

Anyway, some possible choices for consensus might be that:

1 mi.^{2} or km^2 out of 10 has fossil fuel under it; or
1 mi.^{2} or km^2 out of 100, or
1 mi.^{2} or km^2 out of 1,000, or
1 mi.^{2} or km^2 out of 1,000,000, or
1 mi.^{2} or km^2 out of 1,000,000,000?

Encourage choice of both an upper and a lower limit. Then calculate the area(s) in square miles or square kilometers that these limits represent.

4. Now consider one other limitation. Granted that so much surface area may have fuel under it, how thick is the deposit likely to be? Let students decide. However, you may want to remind them of a few facts.

- Earth is only 4,000 mi. or 6,400 km "thick" from the center outwards.
- The greatest depth to which humans have explored the "rind" is six miles (deepest borehole was drilled in Oklahoma in 1974).
- Sixty-three percent of the coal mines in the U.S. are based on seams three feet to six feet thick.
- Depth of petroleum and gas pools can usually be measured in feet, yards, or meters. None over 50 yards are known.

Anyway, decide on some average depth. Then calculate the total volume of fuel reserves available by your class estimates.

Example: If you used mile units, your continental area calculations will be in the range of $57\text{-}70 \times 10^6$ sq. miles, depending when how much continental margin or shallow ocean area your students are willing to include. Let's use 60×10^6 mi^2 as a "ball park figure." Suppose the "range" of fuel-covering area (or the upper and lower limits chosen by the class) is one-tenth to one-millionth of that or 60×10^5 mi.^{2} (maximum) to 60 mi.^{2} (minimum) surface area.

Next, assume an average depth of 10 feet or 1/528 of a mile (0.0019 mi.) is selected as the average thickness of fuel deposits. Then the volume of deposits would be:

(0.0019 mi.) x (60 x 10^5 mi.) = 0.114 x 10^5 $mi.^3$ = 11,400 $mi.^3$ (upper limit) and
(0.0019 mi.) x 60 mi. = 0.114 $mi.^3$ (lower limit)

5. Some conversions are now necessary. "Official" estimates of fuel reserves are usually calculated in barrels (for petroleum) or in metric tons (for coal). Therefore the next steps will be:

   a. Estimate how much of your fuel deposits are oil, how much are coal.

   b. Apportion volumes accordingly.

   c. Convert coal volume to metric tons. Assume that 1 m^3 coal deposit yields 1 metric ton or 2,200 lbs. of coal at the surface, or assume that 1 $yd.^3$ underground coal deposit yields 1 short ton (2,000 lbs.) of coal.

   d. Calculate the volume of petroleum (by your estimates) at the rate of 6.3 gal./m^3 or 5 gal./$yd.^3$.

6. Compare the class minimums and maximums with the "official world estimates." Use whatever resources are available to you. The local librarian is usually a good resource person who can locate current data. For your convenience, some estimates follow. These figures come from "Survey of World Energy Sources" by M. King Hubbert, reprinted in Perspectives on Energy, Ruedisili and Firebaugh, eds., New York: Oxford Press, 1978.

Coal--Original world resources were estimated in 1969 (by Paul Averitt of the U.S. Geological Survey) to have been 7.64 x 10^{12} metric tons. Of this amount, M. K. Hubbert estimates that 2.35 x 10^{12} metric tons of it or 2.59 x 10^{12} "short tons" are recoverable, given present technology.

Petroleum--Estimates for total ultimate recoverable crude oil in the world range from 1,350 x 10^9 to 2,400 x 10^9 barrels. (Divide by 6.3 gal. per m^3 or 5 per $yd.^3$

Tar-sand oil reserves--These are estimated by Hubbert at 300 x 10^9 barrels.

Shale-oil reserves--These are estimated by Hubbert at 190 x 10^9 barrels.

Note: If you used metric measurements,
1 km^3 = 1 x 10^9 m^3
If you used English measurements,
1 $mi.^3$ = 5.45 x 10^9 $yd.^3$ = 1.47 x 10^{11} $ft.^3$

Example: Converting Hubbert's figures to cubic yards for comparison to the class estimate figures given in miles (in previous example), we get the following:

Coal at 2.59×10^{12} tons and $1 \text{ yd.}^3 = 1$ ton	2.59×10^{12} yd.^{3} coal
Petroleum at $2{,}100 \times 10^9$ barrels and 5 barrels = 1 yd.^3	0.42×10^{12} yd.^{3} petroleum
Tar sand oil at 300×10^9 barrels and 5 barrels = 1 yd.^3	0.06×10^{12} yd.^{3} oil from sand
Shale oil at 190×10^9 barrels and 5 barrels = 1 yd.^3	0.04×10^{12}yd.^{3} oil from shale
Total volume of fossil fuels stored under Earth's surface (excluding gas*).	3.11×10^{12} yd.^{3} (T_1)

*Gas was excluded because of lack of information on its subterranean volume. Its surface volume exceeds that of all other fuels because of its low density at atmospheric pressure. However, Hubbert has estimated that its contribution to the magnitude of energy stored underground is about 15.7%. From this can be calculated a "gas-equivalent" figure of about 0.58×10^{12} yd.^{3}, and T_2 or total volume of fossil fuels including gas = 3.69×10^{12} yd.^{3}.

$$T_2 = 3.11 \times 10^{12} \text{ yd.}^3 + 0.157\, T_2$$

$$0.843\, T_2 = 3.11 \times 10^{12}$$

$$T_2 = \frac{3.11 \times 10^{12}}{0.843} = 3.69 \times 10^{12} \text{ yd.}^3$$

$$15.7\%\ T_2 = 0.579 \times 10^{12} \text{ or } 0.58 \times 10^{12} \text{ yd.}^3$$

Using T_1 and the figure 5.45×10^9 yd.^{3} = 1 mi.^{3},

$$\frac{3.11 \times 10^{12}}{5.45 \times 10^9} = 0.57 \times 10^3 \text{ mi.}^3 \text{ or } 570 \text{ mi.}^3$$

Using T_2, the calculations are:

$$\frac{3.69 \times 10^{12}}{5.45 \times 10^9} = 0.677 \times 10^3 \text{ mi.}^3 \text{ or } 677 \text{ mi.}^3$$

These totals fall halfway between the 11,400 mi.^{3} upper limit and the 0.114 mi.^{3} lower limit of the original example (point 4).

7. When the class has successfully totaled their estimates of the volumes of fossil fuel available, the next important question is "How long will it last?" Surprisingly, the amounts of fuel estimated by the class and by the experts--even though they may differ by factors of two, four, ten, or more--will last nearly the same amount of time IF the same assumptions about rate of usage are made. This is the subject of the activity, GROWING TIME.

Planet Earth: Some Measured Limits

Dimension	Approximate Value		Official Value	
	Metric	English	Metric	English
Radius	6,400 km	4,000 mi.	6,378 km	3,963 mi.
Circumference	40,000 km	25,000 mi.	40,076 km	24,902 mi.
Avg. ocean depth	4.3 km	2.7 mi.	4,270 m	14,000 ft.
Marianas trench	11.0 km	6.9 mi.	11,040 m	36,198 ft.
Deepest borehole, Oklahoma, 1974	9.6 km	6.0 mi.	9,590 m	31,441 ft.
Mt. Everest	8.9 km	5.5 mi.	8,854 m	29,028 ft.
Mt. McKinley	6.2 km	3.8 mi.	6,198 m	20,320 ft.
Surface area*	5.1×10^8 km^2	2.0×10^8 mi.^{2}	511,187,100 km^2	196,940,400 mi.^{2}
Land surface area*	1.5×10^8 km^2	0.6×10^8 mi.^{2}	148,678,000 km^2	57,280,000 mi.^{2}
Ocean surface area*	3.6×10^8 km^2	1.4×10^8 mi.^{2}	362,508,600 km^2	139,660,400 mi.^{2}
Volume**	10.9×10^{11} km^3	2.7×10^{11} mi.^{3}		
U.S. land area	$.09 \times 10^8$ km^2	$.03 \times 10^8$ mi.^{2}	9,363,123 km^2	3,615,122 mi.^{2}
U.S. continental shelf	$.0004 \times 10^8$ km^2	$.0001 \times 10^8$ mi.^{2}	36,110 km^2	13,942 mi.^{2}

*English units are from World Book Encyclopedia, 1978. The metric units are calculated on basis of the formula for a sphere. Surface area = πd^2, with $d = 12{,}756$ km.

**Volume has been calculated on the basis of approximate values for Earth's radius and formula for a sphere, $V = 4/3\,\pi r^3$.

Squaring "On the Double"

Objective:

To model exponential growth or "doubling time."

Materials:

Sheets of graph paper with 1/4" or 5-6 mm squares.

At least four colored pencils or crayons or colored pens per student.

Watch with second hand or minute-timer.

Procedure:

Tell the students that you will give them one minute to color a square on their graph paper. Of course they don't need that much time, but give them a full minute anyway.

Then ask them to use another color on two squares during the next minute. Ask for a third color and four squares during the third minute. Keep a steady pace with no waiting time between minutes. Ask for eight squares during the fourth minute, etc. until there is no more room on the paper.

Table A

Minute	Number of Squares to Color	Total Colored
1	1 (2^0)	1
2	2 (2^1)	3
3	4 (2^2)	7
4	8 (2^3)	15
5	16 (2^4)	31
6	32 (2^5)	63
7	64 (2^6)	127
8	128 (2^7)	255
9	256 (2^8)	511
10	512 (2^9)	1023

Expected Results:

Depending on size of the squares on the original graph paper, students may be able to color in eight or nine doublings before running out of space. Note to students how easy (plenty of time) it was to color in the first six minutes worth of squares, but how hurried they were during the last minutes of coloring.

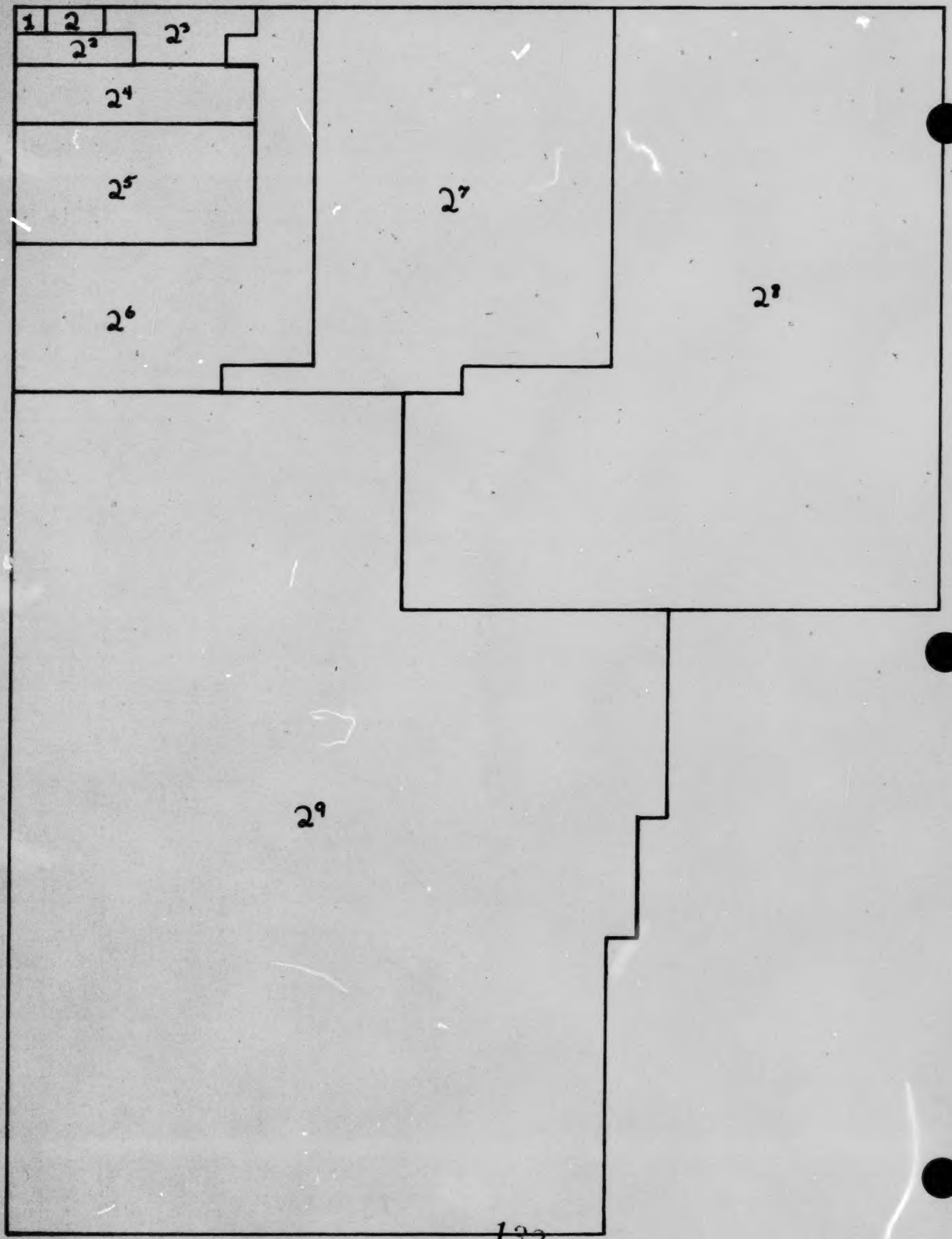
Questions:

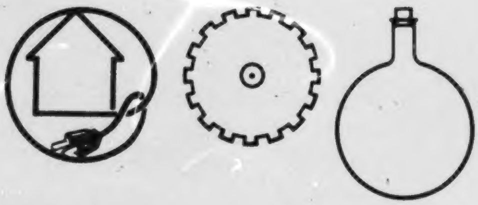
Ask what one would do in order to double the squares one more time. Get another sheet of paper?

Put Table A on the chalk board. Ask students to label their various colored areas with the exponent (power of 2) it represents. Draw attention to the fact that each successive doubling colors an area bigger than all the previous ones put together. This can be seen on Table A also . . . the previous "total colored" is always exceeded by the next doubling.

Now ask, "If we had continued to color only one square per minute instead of doubling every time, how much longer would the graph paper have lasted?"

The answer will be on the order of 1,200-1,500 minutes vs. the 8-10 minutes for the doubling pace (actual figures depend on the scale of the graph paper). Make the analogy to "steady-state" growth and/or use of resources vs. exponential growth or regular doubling of energy consumption, populations, human expectations of material goods.


1
2
2^2
2^3
2^4
2^5
2^6
2^7
2^8
2^9



Thermodynamics: Some Basic Energy Limits

All forms of energy tend to change into heat. Quantitative measures of this trend are called the Laws of Thermodynamics. They are useful to many scientists and engineers. They are also important to every citizen because they help describe some of the energy constraints we may face in the future.

Most laws of physics are not time-bound. They apply to the past, the present, and the future. They permit explanation of past events as well as prediction of those to come. All the laws of motion, for example, are reversible in time.

But the Laws of Thermodynamics "smell more of their human origin" as physicist P.W. Bridgman wrote. They attempt to reconcile man's eagerness to identify "constants" with his actual practical experience with energy.

The First Law of Thermodynamics which states that energy cannot be created nor destroyed is often called the "Law of Conservation of Energy". It is based on the assumption that the amount of energy in the universe is fixed, that only appearances change.

The First Law of Thermodynamics arose out of human experiences with mechanical motion and the heat produced by the accompanying friction. Energy causes motion which meets resistance (of air, water, metal, other materials). This resistance is shown as heat.

Rolling auto tires, rotating drill bits, and falling water all get measurably warmer than their surroundings. Mechanical, electrical, or gravitational energy started those movements in the first place; work was done; and heat energy is a by-product of the motion. But can the heat be recaptured to do more work? Can it roll the car further, drive the bit deeper, lift water uphill again?

Experience shows that such energy recycling is not possible. Even though the quantity of energy involved may be constant, the quality of the energy has somehow been degraded. After conversion from one form to another, the energy available is no longer able to do as much work (or to produce as much power) as the original form would. So having plenty of energy and being able to account for all of it is not enough.

Energy sources are valued for their potential to yield power. That potential is reduced when energy is converted from one form to another. Most of the energy in food is used to keep a mammal warm and breathing; only a fraction is translated into work. Only about a third of coal's potential energy is realized in the production of electricity. Most of the rest is waste heat that does no work. This loss of potential to do work is called entropy, a negative quantity.

The Second Law of Thermodynamics is concerned with the degradation of energy and states that the entropy of the universe is constantly increasing. This second law is really a round-about way of expressing human frustration in encountering another "No-No" in direct practical experience. Man cannot create energy and man cannot keep energy flowing indefinitely to do his work. In other words, energy usage is a downhill process, time-bound and mortal like man himself.

A more general way of stating the Second Law of Thermodynamics is to say that all systems tend to approach a state of equilibrium. Heat naturally moves from a higher temperature area (heat source) to a lower temperature area (heat sink). It never spontaneously moves from a cooler area to a warmer one; that is, it never concentrates itself. Heat tends always to diffuse or spread out, just as a dye does in water. (See activity suggestion following.)

Demonstration:

Show students a large jar of tap water and a small bottle or dropper full of food coloring. Present them as examples of relatively organized, naturally concentrated materials.

Then add several drops of food coloring to the jar of water. Watch the dispersal of color until it is evenly distributed.

Questions:

1. Is the color as intense as it was originally? Why not?
2. How can the food coloring be concentrated again? (Boil off water; let water evaporate slowly.)
3. How can the water be restored to its original state? (Boil it off, catch and condense steam by chilling it.)
4. Do these methods require any energy use? (Yes--hot plate or Bunsen burner for boiling; warmth from room air or sunlight for evaporation.)
5. If we let the jar sit for a few weeks, will the dye settle out at the bottom or form a separate layer at the top? (No, but do it. Then compare the result to diffusion of heat energy into the environment by man's activities, heat we are unable to reclaim.)

Thermodynamics: Entropy - Down With Organization

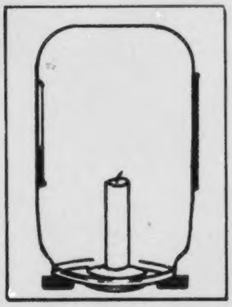
Entropy is a mathematical concept useful to scientists and engineers. It is becoming important in everyday life, too, as we recognize our dependencies on energy resources and attempt to account better for present and future energy usage. Awareness of limitations to the usefulness of energy in general, and most calculations of "net" energy available from particular conversions, grow out of an understanding of entropy.

The unavailability of energy for work, or entropy, is also considered a measure of disorder. Some analogies may be drawn to make this idea more tangible to students. Suggestions follow.

1. Measure the capacity (volume) of a clay flowerpot. (Use a measuring cup, graduated cylinder, or mathematical calculation according to your preferences. Or provide two identical flowerpots for comparison, an "experimental" and a "control" and some material--soil, BB shot, paper clips, rubber bands, etc.--for each to hold.)

   Then drop the pot so that it breaks as it hits the floor. Have students collect the pieces and calculate or measure carrying capacity of the shards. (The volume of soil, shot, etc. that fragments can carry is significantly less than that of the original pot or its unbroken twin. Its capacity to serve is greatly reduced; its entropy or lack of organization has increased.)

2. Demonstrate burning a small candle. Try setting a five-gallon jar upside down on one- to two-inch blocks, allowing air to enter. Center a candle in a non-flammable holder under the inverted jar. Tape a small thermometer onto the inside near the base of the jar and one onto the outside also. Let students record the temperature difference between thermometers as the candle burns low.



Questions:

a. Can you use this heat? Can you recapture the light or use it to do work? Can you reconstruct the candle from its vapors? Can you collect and reuse the carbon on the glass?

b. If you answered "yes" to any of the above, explain your answers. Does your method of recycling involve any additional energy input?

c. If you answered "no" to any of the above questions, what obstacles to success do you see?

d. If you do collect the carbon (soot) from the glass, will it burn and give more heat.

3. Put your house in order.

   If left to themselves, natural systems tend to become more and more disorganized.

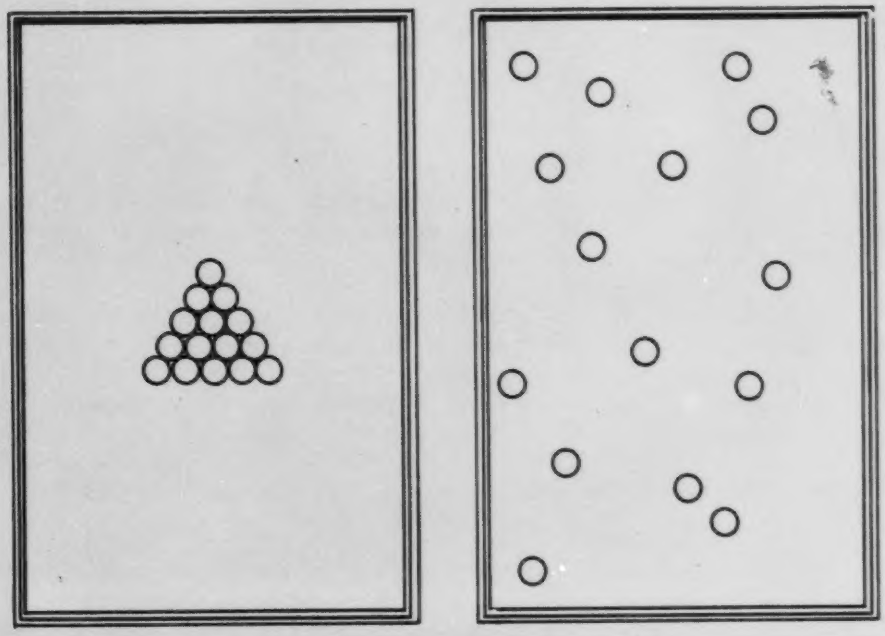
   Use a common experience with houses as an illustration. If a house is not cleaned regularly and kept repaired, it tends to become messy. Some things get scattered, some break down. Neatness and order are reduced. Periodic expenditures of energy are required just to maintain the original condition of the house.

   Another example to consider is the student himself or herself. Each person is a complex, highly specialized organization of parts that tends to come apart unless new energy is put into the system regularly. The fuel for maintaining order (health) is nutritious food.

4. Watch the action, folks!

   This activity was adapted from Energy and Order by Mark Terry and Paul Witt (Friends of Earth, 1976, p. 3).

   On a smooth, level floor or table, outline about a square yard with scrap pieces of 2 x 4's. Arrange 15 ping pong balls or rubber jacks' balls in the center of the square as shown. Have a student put energy into the system by hitting one of the corner balls with a ruler. Next, have students record how many additional energy inputs are needed to get all the balls back into their original positions. Allow use of the ruler or a wooden dowel only-no fingering. Ten to fifteen minutes should be enough time for discovering what is happening.



Discuss the results in terms of energy and disorganization.

Several individual set-ups could be made on a smaller scale. Use marbles instead of balls and 12" squares.

Or each student could do the activity individually, using a shoebox lid with lead shot for the balls and a pencil for their manipulation.

5. Mother Goose Hangs High (or "Energy, where are you when I need you?")

Remind the class of Humpty Dumpty's fate:

Humpty Dumpty sat on a wall,
Humpty Dumpty had a great fall.
All the King's horses and all the King's men
Couldn't put Humpty together again.

As he sat on the wall, Humpty Dumpty was a well-organized arrangement of his physical components. He also had potential energy due to his high position. When he fell, the dear egghead smashed into a disorderly splatter of liquid and solid ingredients.

Questions:

a. Think of Humpty Dumpty as an energy source. How is this event explained by the Laws of Thermodynamics? (All of his physical components lay on the ground. None were lost, as the First Law of Thermodynamics states. The arrangement of Humpty was very disorderly and unrecognizable, however. Also it resisted human efforts to restore its original state, in accord with the Second Law of Thermodynamics.)

b. What losses did Humpty Dumpty suffer? (He lost most of his useful energy or gained entropy. His "lifetime" was cut short. His value as a wall ornament, potential to do work, and concentration as a food source are all drastically reduced by his fall.)

c. After the fall, was Humpty Dumpty useless as an energy source? (He may not have been wholly useless. True, his energy of position is irretrievable and his scattered yolk and albumin may no longer be suitable for fueling large organisms like King's men. But some droplets of egg may be available to smaller organisms--ants, molds, bacteria, etc.--thus a fraction of its gross energy potential may be converted to work as a secondary step in the escalation of entropy.)

d. If he knew when he was going to fall, could Humpty-Dumpty have been more energy-efficient? (He might have pushed a paddle wheel, activated a lever, pulled a pulley-rope, aimed to land on the up-seat of a seesaw in order to propel another egg upward, etc. Consider a variety of simple machines--encourage students to brainstorm this and list suggestions on the board for elaboration or combinations.)

e. What is the message here for a throw-away society?

Thermodynamics: Heat Engines and the Second Law of Thermodynamics
(or "You Can't Break Even")*

Modern technology demands far more energy than can be supplied by men and beasts, even with the help of machines. Instead, it makes use of heat engines which consume fuel to produce heat and convert the heat into work.

It was learned through experiment that the potential energy in a fuel could never be completely converted into work. Some was always lost to the surroundings. We say "lost" only in the sense that this energy was no longer available to do work. What it did, instead, was to warm the environment.

Men had tried to invent heat engines that would convert all the energy of a fuel into work, but they always failed. It was found, instead, that a heat engine could be made to work only by the following two sets of processes:

a. Heat must be absorbed by the working parts from some hot source. The hot source is usually provided when some substance such as water or air (called the "working substance") is heated by the energy obtained from a fuel such as wood, coal, oil, or uranium.

b. Waste heat must be rejected to an external reservoir at a lower temperature. A heat engine cannot work any other way.

To help us gain further insight into this very fundamental concept, we are going to describe an imaginary situation--a problem--that can be solved only by doing work.

The problem is this: A landslide causes a large boulder to roll downhill. It comes to rest where it blocks the entrance to a cave home, and a primitive man wishes to remove the obstruction. What can he do?

He could perhaps get some of his family or friends to help him push it out of the way. Or he may have domesticated a large animal and could use it to do the work.

He would be even more likely to succeed if he could apply knowledge of simple machines. The lever, the wheel, the roller, the screw, the inclined plane (and later, the gear and the block and tackle) were all devices that could increase the force that a man or his animals could exert.

These three techniques--cooperation among peoples, use of animal power, and the application of machines--enabled man to build the pyramids of Egypt, the Great Wall of China, and the cities of Athens, Rome, and Carthage.

Adapted from Amos Turk, Ecology, Pollution, Environment, W.B. Saunders, Philadelphia, 1972, pp. 176-181. Used with permission of both the author and publisher.

But let's look at a more "modern" way of moving that boulder. Imagine that the cave man discovers that he can move it by wedging a bar of cooper between it and the cliff and then heating the bar with a flame. Because heated metal expands and the cliff is stationary, the boulder will move. He has constructed a basic heat engine. Now let us assume the following circumstances:

a. The man who wants to move the boulder has several copper bars, each ten meters long.

b. It is very awkward to build a fire under the copper bar between the boulder and the cliff, but it is convenient to have a fire nearby to heat the copper bars to the temperature of 100°C.

c. The outside temperature is 20°C.

d. The bar expands 0.17 mm for every degree of temperature rise.

The cave man, thinking he has discovered that hot copper bars can do work, heats one of his bars on the fire, wedges the hot bar between the cliff and the rock, then waits and watches. The bar cools and contracts, and no work is done.

This failure teaches him his first lesson in the design of heat engines: Work is done only by heating materials and allowing them to expand. Therefore, temperature differences rather than absolute temperatures are important.

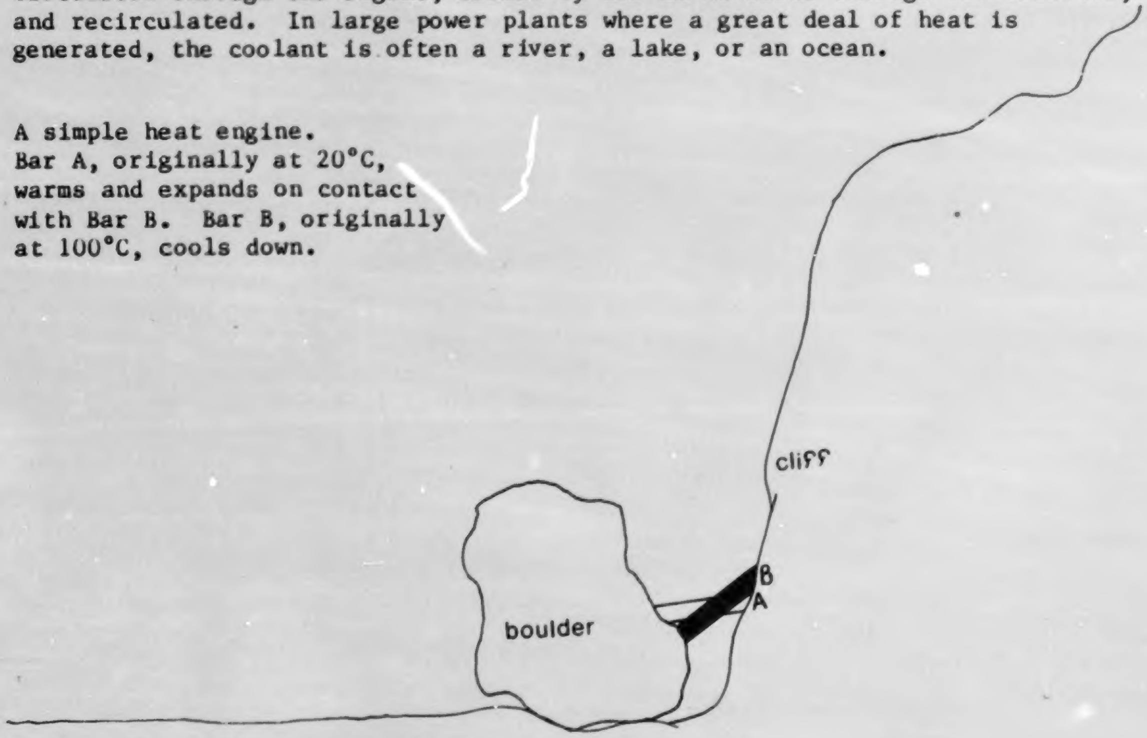
Our cave man now decides to wedge a cold bar between the rock and the cliff and to bring hot bars to the cold one. He heats three bars to 100°C. He places the first bar on the cold one, as shown in the picture. The cold bar gets warmer and expands while the hot one cools and contracts. When both reach the same temperature, all heat transfer (and hence all work) stops. The temperature of the working bar rises from 20°C to 60°C while the temperature of the heating bar drops 40 degrees. The final temperature of both bars is 60°C.

In order to move the rock further, the cave man places the second hot bar on top of the working bar and observes that the working bar warms from 60° to 80°C, and the new hot bar cools from 100° to 80°C. For every degree rise, the working bar expands 0.17 mm. Thus, the first time he heats the bar, the rock moves 6.8 mm. The second time it moves 3.4 mm. The last time it moves only 1.7 mm. Therefore the amount of work that can be extracted from a given quantity of heat depends on the temperature difference between the hot and the cold bars.

If the cave man were clever, he would not need to tolerate a diminished output of work after use of each successive hot bar. Instead, after each heating, he would cool his working bar back to 20°C in some nearby stream, replace it on the cliff (with an additional stone wedge to make it tight), and move the boulder a full 6.8 mm for every hot bar he used. He is now getting more benefit from the hot bars, but at some additional expense of human labor and energy and input of still another resource, the energy-exchanging water. He would be like modern man, then, because his advanced technology would have caused thermal pollution of his stream.

We use complicated heat engines today, but the relationships between work and heat have not changed. The working substance is generally a gas that expands to do work against a piston or the blade of a turbine. The gas cools as it does its work, but it cannot cool below the temperature of its surroundings. Therefore some provision must be made to remove waste heat from a heat engine.

In practice, cooling is generally accomplished either by blowing air past the engine or by running water over it. In most automobiles, for example, water is circulated through the engine, cooled by air as it flows through the radiator, and recirculated. In large power plants where a great deal of heat is generated, the coolant is often a river, a lake, or an ocean.



A simple heat engine. Bar A, originally at 20°C, warms and expands on contact with Bar B. Bar B, originally at 100°C, cools down.

Questions:

1. What methods for moving the boulder are mentioned in the article?
2. What other ways can you suggest to more the boulder?
3. Which of the methods (mentioned in your previous answers) use the most energy?
4. Which would use the least energy but still move the boulder?
5. Which way would have the most environmental side-effects?
6. Which method of boulder removal would you try first if it was your problem? Give reasons for your answer.
7. Now assume that your youngest child is still behind the boulder, trapped in the cave without food or water. Would this affect your choice of method? Explain.

Teacher's Guide to Heat Engines

Dr. Turk's analogy of a boulder-moving device as a heat engine is an idealized example. You may want to point out that there would be heat losses of the bar to the air as the man carries it to the site, so the heated bar would no longer be 100°C when it reaches the working bar. Also more heat would be "lost" during the time required to reach equilibrium. Then when both bars are at equilibrium (some temperature less than the 80°C assumed possible if no losses occurred), they are temporarily warmer than their surroundings and will lose heat, over time, to the environment.

The cave-man example illustrates a key concept in energy education. Energy comes from some source, is used by living things, and is always less available for work afterwards. This is unlike Isaac Newton's claim that "For every action there is an equal and opposite reaction." Also, the idea of side-effects or "costs" of energy use is introduced. Everything we do affects something and/or someone else.

Hopefully, awareness that time is important will emerge from the questions. Some students may suggest that nature alone (freeze-thaw, action of lichens and mosses, chemical reactions with rainwater, etc.) will eventually move the boulder or disintegrate it. A person may use less energy by finding another cave for shelter, and letting nature take its course. Others, in a hurry, may suggest dynamite, jackhammers, powerful chemicals, bombs. The plight of the child also interjects a note of urgency that may make some change from a less- to a more-energy intensive solution in order to save time. However, the quickest solutions may also be life-threatening.

This should help highlight the impossibility of making wholly satisfactory choices. There are no "easy" answers. Every energy use has disadvantages as well as advantages.

Blowing in Some Cents

The Story:

"A windmill's effect on its owner is powerful and seductive. All you have to do is buy it, raise it, point it toward the wind, switch on the lights, and relax--a quid free of the quo, jubilee!

"Well, it isn't that easy. I heat my house with oil and cook with gas. My lights, television set and stereo, well pump, refrigerator, freezer, washer and dryer, a few power tools--these cost me slightly more or less than 700 kilowatt-hours per month. But to obtain the same amount of energy through wind power, assuming a windy enough location, would require a capital investment of $16,500."

--Geoffrey Wolff, Quest/78

Some Facts:

As of January 1, 1979, customers of New York's Consolidated Edison were paying $62.06 a month for 750 kwh of electricity. Hawaiians were charged $62.51 for the same amount. Washington Water Power Company (State of Washington) was charging least of all investor-owned power companies in the United States: $12.20 for 750 kwh of power. In Iowa, customers of Iowa-Illinois Gas and Electric paid $40.69 a month for this rate of use.

Falling water is a cheaper power source than fossil fuels. (Nuclear can be considered "fossil" in the literal sense of the root word, meaning "dug up.") But can windpower match the delivered cost of New York's electricity if Mr. Wolff's figures for installation of a windmill are correct?

Questions:

1. If Mr. Wolff lives in the state of New York, what does he pay per month for 750 kwh of electricity (at January 1, 1979 rate)? ____________________

2. How much is this per year? ____________________

3. Let your answer in question 2 represent the savings from use of a windmill that Mr. Wolff could expect in 1979. If he paid cash for his windmill, what percent of return on his capital does this represent?

   ($ saved ________ ÷ $ invested ____________) x 100% = __________

4. At this rate of return, how many years will he need to recoup his initial investment?

   Use the formula $\frac{70}{\%\ \text{return}}$ = years

5. If he does not buy a windmill, Mr. Wolff can invest his $16,500 at 9-10% in a special account at his local bank. Assuming his money earns only 9% simple interest, does it earn enough to pay his electric bills?

6. Based on your answers above, do you think that Mr. Wolff's decision was based on family economics?

7. What factors might change Wolff's decision?

8. What would be the advantages to owning your own windmill?

9. What would be the disadvantages?

Teacher's Guide to Blowing in Some Cents

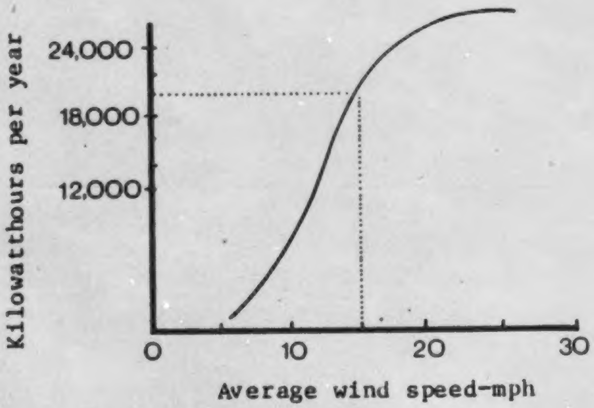
Although the energy source for a wind machine, moving air, is free, the equipment to convert that energy to useable form can be expensive. There are a number of methods for determining the cost of using wind. One is to estimate the cost of electrical generation by windmill using the following formula:

$$\$/\text{kwh} = \frac{(\text{capital cost})\ (\text{annual charge rate})}{\text{annual kwh production}}$$

The capital cost includes all expenses of the windmill including construction, delivery, and installation. This may be reduced by any available incentives such as the federal income tax credit.

The annual charge rate represents the interest, depreciation, taxes, operation, and maintenance as a percent of the capital cost. Although this varies widely with local circumstances, the American Wind Energy Association considers 18% as a typical annual charge.

The annual kilowatt hour production will vary from machine to machine and from site to site. However, manufacturers and distributors can usually provide a simple graph such as the one included here.



This graph can be used to make a gross estimate of the power that will be produced annually at various wind speeds. For example, if the machine represented by the graph were purchased for $16,000 completely installed, the cost of electrical generation at a site with 15 mph winds would be:

$$\$/\text{kwh} = \frac{(\$16{,}000)\ (.18)}{20{,}000} = \$.144 \text{ or } 14.4 \text{ cents/kwh}$$

If this windmill were in New York in 1979, its electrical generation at 14.4 cents/kwh is more expensive than the 8.3 cents/kwh charged by Consolidated Edison. However, commercial utility costs have increased rapidly and are likely to do so in the future. It is not possible to predict what average commercial cost/kwh will be over the life of the windmill. The cost/benefit ratio may change.

Also, this type of windmill is the most expensive kind. Windmills to pump irrigation water, or to warm water (see article in YE OLDE TIMES, SUN PRESS, and STAR GAZETTE included in this handbook), cost much less--$3,000 is the current quote for a conventional pumper--and are more likely to yield immediate economic benefits.

Answers Expected:

1. $62.06

2. $744.72

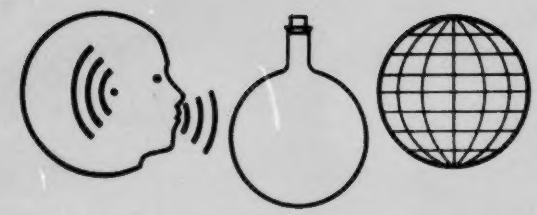
3. 4.5%

4. About 15.6 years

5. Yes, with dollars to spare. At 9%, his capital earns $1,485 vs. $744.72 in electric bills.

6. Yes, because the investment in a windmill shows a low return by today's standards.

7. Higher utility bills, lower earnings on his capital, lack of commercial electricity at any price, environmental threats by conventional power generation, desire for greater self-sufficiency, etc.



The Energy Debate

Background:

Seldom have people living in a democratic society had so much conflicting information and so many opinions showered on them as have been spawned by the great energy debates.

Some facts seem certain. Energy availability affects everyone. Fossil fuels will not last forever. We will have to make some choices and plans in order to avoid energy disruptions in the future.

Other elements of energy talk are not so easy to evaluate. Data is missing or is interpreted differently by various interested groups. Opinions and priorities differ widely even among "experts". Examples of fact, opinion, prediction, and persuasion are included in the following selected quotations.

Activity Suggestions:

1. Classify the quotations according to type. Use the categories suggested in the previous paragraph or devise your own.

2. Choose a favorite quotation (from those included here or another energy-related one you chose from your readings) and write a paragraph elaborating on its key idea or a paragraph stating reasons for your choice of this particular statement.

3. Develop a short essay or speech including one of the following quotations in it.

4. Write two or three "statements" about energy that you predict will be appropriately spoken by prominent world citizens twenty years from now; one hundred years from now.

5. Write a brief rebuttal or contradictory statement to several of the quotations provided.

6. Imagine that you are in charge of a radio-TV campaign to convince people that conserving energy is a vitally important national strategy.

   a. Which quotations would strengthen your appeals on radio?

   b. Which speakers would you interview or feature on TV?

The Energy Debate:
Comments and Controversy from Home and Abroad

Everything is connected in ways we cannot begin to imagine. The hunger problem is not the hunger problem. It is the poverty problem. It is the pollution problem. It is the energy problem. It is the war problem, the arms problem. All those problems are inextricably connected, and you don't solve one without solving them all. Things that will work for one will work for all.

Dana Meadows--systems analyst
speaking at the 1978 World
Hunger Symposium

The sun radiates energy at a rate of 400,000,000,000,000,000,000,000,000 watts. Half a billionth of that gets to the earth. Of that fraction, about a third bounces off immediately and almost another third remains at the surface to drive the climate. Living things, intertwined by their individually tiny but collectively vast flows of energy, have been evolving for several billion years within the constraints of energy income available to them. They work very well and know exactly what to do, even though they have never been to engineering school.

Jim Harding, 1975

The United States puts 45% of its total energy into vehicles: to make them, run them, and clear a right of way for them when they roll, when they fly, and when they park. Most of this energy is to move people who have been strapped into place.

For the sole purpose of transporting people, 215 million Americans allocate more fuel than is used by 1,300 million Chinese and Indians for all purposes. Almost all of this fuel is burnt in a rain dance of time-consuming acceleration.

Ivan Illich, Energy and Equity, 1974

I blame squarely the West for certain models that they have introduced to us; one is the consumer society, the other is gigantism. We are still stuck with them. The gigantism: big dams, big projects, roads, cars for everybody. We cannot afford cars for everybody; not even one person in one hundred has a car. We must have mass transportation. We took the wrong road for a number of years. We are now realizing we're on the wrong road but it takes a long time to make a turn.

Ajit Bhattacharjea--Editor, Indian Express newspaper, New Delhi, India

---

The diversity of soft technology makes it particularly easy to recycle existing industry, especially the car industry which doesn't have a good long term future. General Motors, I understand, has recently converted a car radiator factory to make solar collectors which are, more or less, car radiators inside out.

Amory Lovins, 1978

The whole universe, including that which we call physical, can be treated in terms of information, and it is clear that information is constantly increasing. The supply is essentially unlimited, for we can always generate new information in the universe of the self--make new discoveries, new choices, put old things together in new ways--and this is bound to influence the future. To influence the future consciously, then, taking responsibility for the outcome of this influence, is to participate fully in the ultimate adventure.

George Leonard, The Silent Pulse, 1978

A General Public Utilities survey shows that 58% of its customers have altered household routines to help cut down the use of electricity in the day time. This means more nighttime laundering, baking, and dishwashing.

Wall Street Journal, August 24, 1978

Energy = potential wealth. Energy is actual wealth if its rate of conversion through work is rapid enough to stem natural chaos and leave a residue of arbitrarily spendable time. Wealth does not come from a bank. It is not gold. Man's moral necessity to 'work' is highly valid and therefore his essential religion.

R. Buckminster Fuller, Nine Chains to the Moon
1963

China's several hundred million (of people) use less electricity for all purposes than the United States uses for air-conditioning alone, and the U.S. is two hundred fifty times more demanding of energy for its wet-rice culture than is China.

David R. Brower,
President, Friends of the Earth

If we adopted a high-priority national program emphasizing energy-efficient buildings, we could by 1990 be saving the equivalent of more than 12.5 million barrels of petroleum per day . . . . The decision is not whether to modify functional demand or behavior or level of comfort; rather, it is whether to invest capital to waste energy or to utilize that same capital to conserve energy.

American Institute of Architects, 1975

A vigorous conservation program will permit us to bridge the next twenty-five years without becoming hooked on either hazardous energy technologies or unreliable sources of supply. Energy conservation will make more net energy available per dollar spent than any other energy supply option, and will allow us to minimize the environmental degradation associated with all current energy production technologies.

Denis Hayes, 1976

Material thrift has become almost impossible; the system conspires against it. As a society, we assign the highest value to our leisure and therefore a lower value to all things that might demand our time and attention. Disposable, self-cleaning, self-defrosting, easy-to-use, ready-to-wear, ready-to-eat, three-in-one, all-purpose--these are the adjectives that get our consumerist juices churning. No matter that the time most of us save we then fritter away in front of the garrulous TV.

Carll Tucker in Saturday Review, August, 1979

Warning: This air conditioner is hazardous to your health and to the environment. This model, used in normal operation in your locale (1000 hours in the summer months) will require the consumption of a pound of coal (or equivalent fuel) per hour of operation. This air conditioner will consume a half ton of coal during the summer, most of which comes from strip mining. In addition, the generation of pollutants from the electric power plant where the coal is burned may cause disease and property damage. The Surgeon General . . . advises use of trees for cooling and shading, natural ventilation when possible, and alternatively, when necessary for mechanical ventilation, the use of electric fans which consume one tenth the energy required for this machine.

Air conditioner label suggested by Wilson Clark in Energy for Survival, 1975

Any dramatic rise in water usage will force . . . hard choices . . . . It takes only seven gallons of water to refine the equivalent of a billion BTU's from Standard Oil of California's Richmond oil refinery. But it takes twice that much water to get the same energy from nuclear reactors and three to four times as much that amount to get it from oil shale. In addition, many of the "new generation" fuels, like geothermal, also consume much more water when they are used to generate power.

Kathleen Wiegner in Forbes, August 20, 1979

The Second Law equation says that energy cannot be recycled, and that matter can only be recycled by expenditures of energy--always at less than 100% efficiency. When we ignore the Second Law of Thermodynamics, we do so to the dismay of our land and air and water. These are the components of the biosphere that must act as a blotter for the Second Law wastes we generate as we use energy.

Jean Matthews in Trends, May 1979

One of the peculiarities of the human animal is his lack of group providence . . . as a social creature he will not accept any warnings that interfere with daily business.

Donald E. Carr

We should build the south side (of the house) loftier, to get the winter sun, and the north side lower to keep out the cold winds.

Xenophon, Greek historian, 400 B.C.

Few will have the greatness to bend history itself, but each of us can work to change a small portion of events, and in the total of all these acts will be written the history of this generation.

Robert F. Kennedy

Man on a bicycle can go three or four times faster than the pedestrian but uses five times less energy in the process. He carries one gram of his weight over a kilometer of flat road at the expense of only 0.15 calories. The bicycle is the perfect transducer to match man's metabolic energy to the impedance of locomotion. Equipped with this tool, man outstrips the efficiency of not only all machines, but all animals as well.

Ivan Illich

Our most optimistic estimates indicate that solar electric generating capacity might represent about one percent of the total installed capacity by the year 2000. Despite accelerated research and development efforts in alternative energy forms, sources other than fossil and nuclear fuels will be supplying only about ten percent of electric generation by the year 2000—and more than half of that will be hydroelectric.

H. V. Young
Edison Electric Institute

Some would say that no nuclear source can be clean and safe; and that though nuclear power is admirable when properly sited, the source and user should be rather widely separated--say, about 150 million km.

Amory Lovins, 1975

Lord Mildew's dictum: "There is no precedent for anything until it is done for the first time."

A. P. Herbert

In our dynamic, pluralistic culture, our decisions will be made at the points of tension between competing value systems. Some of these tensions have long been with us but are now taking on a new significance. For example . . . it is a basic tenet of American social philosophy that economic and social activity are primarily to serve private and individual, not public and communitarian, ends. Public ends are conceived . . . as a pragmatic summation of diverse private ends. This value structure, this very individualism that has enabled Americans to accomplish so much materially, has nurtured the primacy of economic and technological values over spiritual and humanistic ones, and has long kept people from coming to grips with their own tragedies of the commons.

Amory Lovins, 1977

"Thrifty" and "thrive" have a common root of meaning from the Old Norse language. Prosperity and vigorous growth through economical management were implied in thrift or thrif.

Nuclear power does not represent a large reservoir of cheap energy capable of being mobilized very simply and quickly; it is on the contrary one of the most complex and unforgiving technologies known to man.

Amory Lovins, 1975

Until recently, discussion of energy in Sweden was scanty. The criticism offered from several directions was not answered, but rather ignored. It is only recently, within the past year, that international discussion broke the logjam and it became widely held that Sweden was driving with the accelerator floored into a blind alley. Government and politicians are so strongly bound by established political traditions that a reorientation of these is not in the cards; yet, a highly informed and sufficiently broad public opinion has the strength to make its voice heard.

The energy debate will therefore become a crucial test of democracy, and it is exceptionally important that everyone take a stand.

Hannes Alfvén, 1974

The energy in one US gallon of oil is equivalent to one and a half weeks of a fine diet of 3000 food calories per day (more than most of the world's people get). The gallon lasts less than ten minutes in a fast car. A Concorde SST consumes it in about a tenth of a second. Millenia were required in putting the gallon together.

Jim Harding, 1974

Power is not one of the ends of life, but merely the means to other ends, and until men remember the ends that power should serve, science will not do what it otherwise might to minister to the good life.

Bertrand Russell

Real wealth is knowing what to do with energy.

R. Buckminster Fuller

The time has come to inquire seriously what will happen when our forests are gone, when the coal, oil, and the gas are exhausted,

Theodore Roosevelt, 1908

153

Ironically, the fossil fuels we now devour at an astonishing rate are composed of the leftover food of that prime example of immoderate growth--the dinosaur. Rather than learning from history's mistakes, we are burning the evidence.

Denis Hayes, 1977

An annual energy savings of 144 trillion BTU's achieved by the nation's switching to refillable-container systems would result in a net job increase of 117,000 jobs.

FEA report, Energy and Economic Impacts of Mandatory Deposits, September, 1976

A man who cannot fill his bathtub because the water keeps running out does not need a bigger water heater; he needs a plug.

Malcolm McEwen

We envision a new society, less despoiling, more conserving of the biosphere and the planet's resources; it would be one in which biological systems, driven by renewable energy sources like the wind and the sun, would provide the food and other vital inputs for human communities.

Whenever possible we try to incorporate in our designs renewable energy sources and durable materials, rather than finite resources and short-lived materials. Conserver societies must be founded upon such shifts in energy production and use of materials.

John Todd of New Alchemy Institute, 1977

The important issues of energy strategy are not technical and economic but rather social and ethical, and cannot be properly framed by those whose vision is purely technical: "their belief in the effectiveness of power blinds them to the greater effectiveness of abstaining from its use."

Ivan Illich, 1974

The following is an editorial from a French weekly newspaper, Le Nouvel Observateur, Paris, April 9, 1979:

Taking Conservation Seriously

It is possible to conserve energy without depriving ourselves. It won't even be necessary to turn out lights. Public lighting represents only 1 percent of France's consumption of electrical current, the lighting of homes represents only 2.5 percent. In the home, the real waste lies elsewhere.

Self-cleaning ovens use five times more current to clean themselves than to cook a roast. They should be banned. Central heating uses two to three times less energy than electric heating generated by a power station. Energy consumption by washing machines and dishwashers can be reduced at least 70 percent if they are connected to the home-owner's hot water system. Badly insulated refrigerators and freezers use four to five times too much energy.

Another effective energy-conserving measure is recycling. Every household throws out an average of 250 glass bottles a year (a pint of oil is needed to make one bottle) and 350 pounds of paper (three pounds represent a quart of oil). Much waste can be salvaged or recycled. The Scandinavians have receptacles in each bulding for this purpose.

Industrial consumption of energy exceeds household consumption by 20 percent. Everything needs to be reexamined: building insulation, heat regulation and recovery of lost heat, boilers, and other equipment. We should train thermal specialists, as the Japanese do.

Michel Bosquet

The OPEC countries' petrodollar accounts would shrink significantly if Americans should decide to take conservation seriously. They are among the greatest energy wasters in the world. This is due in part to the poor insulation and light construction of most American housing, to the American taste for heated swimming pools, to their gasoline-devouring driving practices, and to outdated power plants and industry.

from the magazine Stern,
Hamburg, Germany, April 1979

After Three Mile Island . . .

For the first time, safety engineers will be able to work on something that has really happened rather than on assumptions, and progress is sure to follow. The public will be less and less willing to be kept in the dark about the dangers involved in producing electricity from nuclear energy, and to be deprived of detailed information about contingency plans . . . The public is sufficiently adult to realize that without the help of nuclear energy, at least for a time, the entire economy would regress to the level of underdevelopment. Nuclear-powered electrical energy hasn't killed anyone yet . . .

article in Le Monde, (French
newspaper), Paris, April 2, 1979

Note: France imports 75% of her energy needs and has a sizable investment in nuclear power. In 1979, France boasted 15 working reactors, had 27 under construction, and started building 5 more.

It is pointless to talk of tightening the safety systems or the licensing procedures; they are already so tight that it has been almost impossible to get approval for building nuclear plants in the U.S. However carefully it is designed, a piece of mechanical engineering can and will fail; however "foolproof" the safety system, it cannot be made proof, as the nuclear industry itself says, against bloody fools. The question is not whether accidents can be prevented; they cannot. It is whether the public is prepared to live with accidents like Three Mile Island. It is perfectly prepared to live with air crashes, in which hundreds die, in exchange for mobility.

Nigel Hawkes, Observer,
Foreign News Service, London,
April 3, 1979.

There are some smart people who think that nuclear power will make a comeback. They point out that the U.S. cannot go on running up ever-higher oil import bills. They argue that a widespread return to coal, as might seem logical, would involve a cost in environmental hazards and labor problems that the country cannot pay. When these facts are recognized, the argument goes, the country will look at Chicago--where Commonwealth Edison efficiently, cleanly and economically gets 45% of its power from nuclear plants--and say: "Nuclear is the best bet."

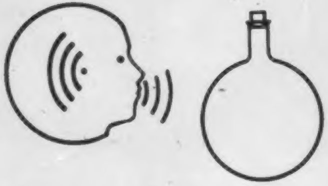
Jean A. Briggs,
[illegible]bes, Jan. 22, 1979

A people can be just as dangerously overpowered by the wattage of its tools as by the caloric content of its foods, but it is much harder to confess to a national overindulgence in wattage than to a sickening diet. The per capita wattage that is critical for social well-being lies within an order of magnitude which is far above the horsepower known to four-fifths of humanity and far below the power commanded by any Volkswagen driver . . .. Calories are both biologically and socially healthy only as long as they stay within the narrow range that separates enough from too much.

Ivan Illich, Energy and Equity, 1974

High-energy society's values and institutions teach that human labor is to be avoided--i.e., that it is bad--and that machine labor is to be desired--i.e., good. Even in the apartment buildings and condominiums of the high-energy society . . . the washing machines, clothes dryers, televisions, and countless other examples of household mechanization are not shared by the concentrated human dwellers. High energy values teach that happiness and success are measured in terms of each dweller's accumulation of machinery rather than in the use of machines that might be shared by all.

Wilson Clark, Energy for Survival, 1975



Energy and Poetry

__Introduction__:

A small group of poems is included here as a sample of several very personal insights that can expand the reader's perspectives on energy. Maybe they will get you started on a collection of your own. Or better, maybe one will inspire you to try thinking and writing about the importance of energy and its relationship to all that moves, warms, and enlightens us.

__Background Commentary__:

THE ENERGY OF POETRY are two statements expressing belief in the power and usefulness of words. Do you agree with the writers?

SNOW BLIND speaks directly of the danger of reflected light as well as of the intensity and lingering value of a peak experience. "Rainbows" have both scientific and romantic connotations worth comparing.

MODERN ART turns a "pre-pollution control devices" cityscape into a melancholy personal remembrance.

NO MORE SECONDHAND GOD is an unusual and loving tribute by one of the most creatively energetic men of the twentieth century. He adds new vibrations to the word "revolution" and seeks order in disorder. The flow of words unwinds like a spring, coiled energy itself.

SOMETIMES can be read as a nostalgic antidote to "future shock," or as another reflection on *MAN, ENERGY, ENVIRONMENT* mentioned elsewhere in this publication. Use of concentrated power sources has greatly accelerated the pace of life and put conflicts between man and his natural home. Many people have never heard the brotherly sounds of wind and bird. That makes the last question, "How can I answer?," even more poignant.

BUT THE WISE PERCEIVE THINGS . . . is a statement from a Greek poet who recognized that the gift of imagination should be used to consider alternatives. This is true regarding any problem facing human society, including those of energy dependencies. As Jonas Salk has written recently, "Wisdom implies making judgments in advance rather than retrospectively, and this is the test which Man now faces."

SUN, SUN POEM, and *BURNING MY BRIDGES BEHIND ME* are three poems from an artist who uses the metaphor of *SUN* liberally throughout her writings. Can you "read into" the first of them an answer to some energy supply problems? recognize another form of sun-blindness in the second? enjoy a celebration of Sun Day with the third? It's worth a trip to the library for more of Diane Wakoski's metaphors.

TO LIGHT THOU SHALL RETURN was written for a local conference on nuclear power generating stations. The writer tried to

1. express ambivalence about benefits and risks of energy use;
2. acknowledge life's dependent and powerful role as a temporary energy-converter and storage battery;
3. use as few words as possible.

Did she succeed?

IOWA WINTER SONG was written along I-80 when fields were blanketed under January snows. Yet energy is active in this imagery--note "drifts," "blow," "rippled," "down-thrown light," "flout," and the stored heat in the persistent presence of the dried vegetation. This poem is so visual that it would be easy to recognize a drawing or photograph made to accompany it.

NATURE"S NATURE is a whimsical explanation of the importance of friction, the energy-eating, heat producing effect of motion. Though it first appeared in a science magazine, its gentle humor give it appeal to the general reader.

Activities:

1. Use these poems, together or singly, as discussion material. Some questions you may use for starters are:
    a. Is it coincidence that each can be read as an "energy message"? (What is the "energy message"?)
    b. Is it the awareness and background of the reader or the intent of the poet that makes "energy" connections?
    c. Have you read (can you find) other poems* or song lyrics that speak of an energy source or man's relationship/dependency on his natural environment?
2. Encourage students to try a short poem of their own. Set limits--maybe a certain number of words or syllables (as in haiku), a particular meter, an assigned topic, or some word play (like having the initial letter of each line spell out an "energy" term).

3. Ask students to illustrate one or more of these poems. Specify media or provide several alternatives you will accept.

4. Have a contest for writing a rhyming energy slogan. Let the class develop the rules, decide how to publish them, select judges, set deadlines, choose an appropriate prize, and invite the whole school to participate.

Some examples from the classics are "Prometheus Unbound" and "Ode to the West Wind" by P. B. Shelley; "A Light Exists in Spring" and "Summer Sun" by Emily Dickinson; "Who Has Seen the Wind?" by Christina Rossetti; many of the oriental poems included in Of all things most yielding, David Brower, ed.

THE ENERGY OF POETRY

The poem has a social effect of some kind
whether or not the poet wills that it have. It
has kinetic force, it sets in motion . . . elements
in the reader that otherwise would be stagnant.

Denise Levertov

Poetry is the ultimate ephemeralization,
doing more with less, making possible
a current between what we feel and what we know,
a high tension wire that has the potential
of carrying into the future
a residual of human energy,
the power of wisdom.

Doris A. Simonis

SNOW BLIND

Having seen the sun
Once and forever,
I remember rainbows
Pale as December.

Doris A. Simonis, copyright 1979.
Used with permission.

MODERN ART

Chocolate night,
Chimneys fuming plumes of rolling smoke--
Every window is oily-painted,
Even fresh snow is early tainted
Like my last unrealized hope.

Doris A. Simonis, copyright, 1979.
Used with permission.

COPYRIGHTED POEM REMOVED

IOWA WINTER SONG

Snow-pied fields of
white-blue, blue-white
hummocky drifts in violet shadows--

Snow and sky blow
white-blue, blue-white
rippled wash of down-thrown light--

Grass stalks, corn shocks, wendy willows
flout yellow, yellow, YELL-oh!
They shout their quiet lives.

Doris A. Simonis, copyright 1979.
Used with permission.

PAGE 328 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

The Greenhouse Effect

Background:

Sunlight that gets through the transparent walls and roof of a greenhouse is soaked up by its contents--the soil, plants, and other materials stored inside. The heat they radiate warms the air and it rises, but the air can't get out because the roof acts as a "lid". Even though most of the radiant heat does escape, the portion retained by the air accumulates and the greenhouse becomes warmer and warmer. This is called the "greenhouse effect."

Everyday, large amounts of sunlight pass through Earth's atmosphere and strike the surface. This radiation is absorbed for a short time and then released again as heat waves. The longer wavelength heat waves do not all escape into space. The atmosphere acts as an invisible blanket, trapping some of the energy that flows outward from the surface. Carbon dioxide and water especially have the capacity to trap heat and "put a lid on" its escape route.

Activity:

Make a model of Earth as a greenhouse and measure the effects of solar heating on it. Recommendation: Do this with a partner and synchronize your temperature readings.

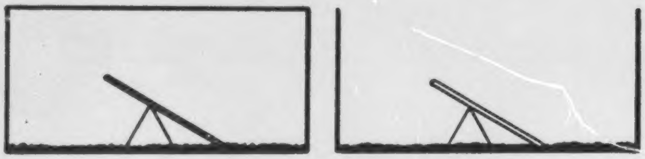
Materials:

2 standard lab thermometers
2 plastic shoeboxes with clear covers
Moist garden soil
Cardboard support for thermometer
200 watt incandescent clear bulb (optional) and mounting stand
Stopwatch or clock with second hand or digital watch

Directions:

1. In each shoebox, spread a 2 cm layer of garden soil over the bottom.

2. Cut a piece of cardboard (or use a file card) to stand in the soil crosswise near the middle of each box. Lean the thermometer against it with the bulb end up.



3. Set both boxes on a pad of newspaper in direct sunlight, or, if that is not practical, use the 200 watt bulb. Put it directly over the pair of boxes, about 25 cm from each.

4. Put a lid on one box and leave the other uncovered. Record initial thermometer readings for both. Then turn on the light.

5. Record the temperature in each box every minute for a total of 20 minutes.

6. Turn off the light and keep recording temperatures for at least 15 more minutes.

7. Plot the data from the covered and uncovered boxes on the same graph of temperature (vertical axis) vs. time. Use different colors or solid vs. dotted lines to represent each.

Questions:

1. In which set-up did the temperature increase most?

2. Which box cooled more rapidly?

3. Which box best represents Earth? Explain.

4. Do a little reading about air pollutants, and write a paragraph explaining how they may change the greenhouse effect.

5. Which box best represents a passive solar house? How would you change the model to make it more like a house?

Work Sheet

Student Name________________________

Class________________________

Date________________________

Model features:

1.

2.

Data Sheet:

Time	Model 1 (°C)	Model 2 (°C)

Write and answer assigned questions on the reverse of this sheet.

Extensions:

1. Repeat the procedure but put water instead of soil on the bottom of the box. Time results carefully and keep all other conditions the same. Relate the soil models and the water models to "continent" and "ocean"; how do they compare?

2. Repeat the procedure using a solid (opaque) cover on one box and an aluminum foil one on the other. Also try other lids like waxed paper and wet cheesecloth for comparison. What atmospheric conditions might they represent?

3. Make home-greenhouse models. You'll need a big piece of cardboard, some gravel, rock salt, canning paraffin, Glauber's salt, and newspapers as well as more shoeboxes for this one.

   Using several shoeboxes with clear lids as greenhouse-collectors, cover the bottom of each with equal volumes of gravel, water, paraffin, Glauber's salt ($Na_2SO_4 \cdot 10\ H_2O$) and ordinary rock salt. Keep one empty box as a "control". Set each box outdoors on a newspaper in full sunlight or use a sunny windowsill in the classroom if wide ones are available. Read each thermometer every minute for twenty minutes, following the same sequence of readings each time if you do the activity alone. If you have team members, one per "greenhouse", then make readings simultaneously.

   Then shade all the model boxes with your cardboard and keep recording the temperature every minute for another 15-20 minutes.

   If ice cubes are available, you may want to speed the cooling process by putting some cubes on each lid. Be sure to treat all boxes the same, however.

   Graph your results, putting temperatures on the vertical axis and time on the horizontal one. Use a different colored line for each model's results.

   Write a paragraph describing the heating and cooling similarities and differences you observed, and another paragraph telling what advantages or disadvantages the materials you tested may have as heat storage media.

4. Do some library research on the atmosphere of the moon, Venus, Mars and Jupiter. Which of these planets also have a "greenhouse effect"? Which do not, and why? Prepare an oral or written report on the facts you have read and what contributions they make to the "odds" on finding life on these relatively nearby space stations.

5. Some people have suggested making greenhouses out of old bus and car bodies.

   a. Would this recycling idea work at all? (Support your answer by referring to your own experiences with mini-greenhouses.)

   b. What would be the advantages of the recycled-vehicle idea?

   c. What disadvantages can you anticipate?

Teacher's Guide to The Greenhouse Effect

This activity will probably require three or four class periods.

The first one may include discussion of the solar energy budget (see graphic which you may duplicate) and of the electro-magnetic spectrum. The atmosphere itself absorbs, scatters, and reflects nearly half of the incoming solar radiation (insolation). The surface reflects approximately 5% and temporarily absorbs most of the remainder. Some of that incoming energy drives the water cycle, evaporating tons and tons of water daily.

Very little sunshine (< .001% according to most estimates) is actually absorbed by plants and stored in their tissues for use by other forms of life. Even that remarkable storage on which we are totally dependent would not have been possible if Earth's atmosphere were different or missing. Its selective transmission and insulation moderate Earth's temperatures to the range most supportive of life as we know it.

Some everyday examples of the greenhouse effect can be noted. Closed cars, for example, get very hot inside the windowed passenger area (but stay cooler under the hood and in the trunk, a difference you can measure on a car parked in your schoolyard). South-exposed rooms in a house warm up more rapidly in the daytime then do north-facing ones. Solar collectors use transparent "lids" to selectively let short-wave radiant light in easily but retard the escape of longer-wave heat.

Besides some introductory discussion, the model greenhouses can be assembled on the first day, and data sheets prepared.

The second day (and a third if necessary) should be used for data collection. If at all possible, use the real thing (sunshine). If the time of year or arrangements in your school do not permit this, then use a clear 200 watt bulb or bulbs set about 25 cm above the boxes. You may prefer a reflector-spot or a heat lamp, but these are even less sun-like than an ordinary incandescent bulb. If you use any electrical set-up, observe extra safety precautions AND at least acknowledge to your class that the artificial power source is not "the same" as insolation for the following reasons:

1. An incandescent bulb produces 95% heat and only 5% light;

2. Its proximity to the "greenhouse" along with its more concentrated energy release makes the artificial lamp a "time compressor" so far as rate of heating is concerned.

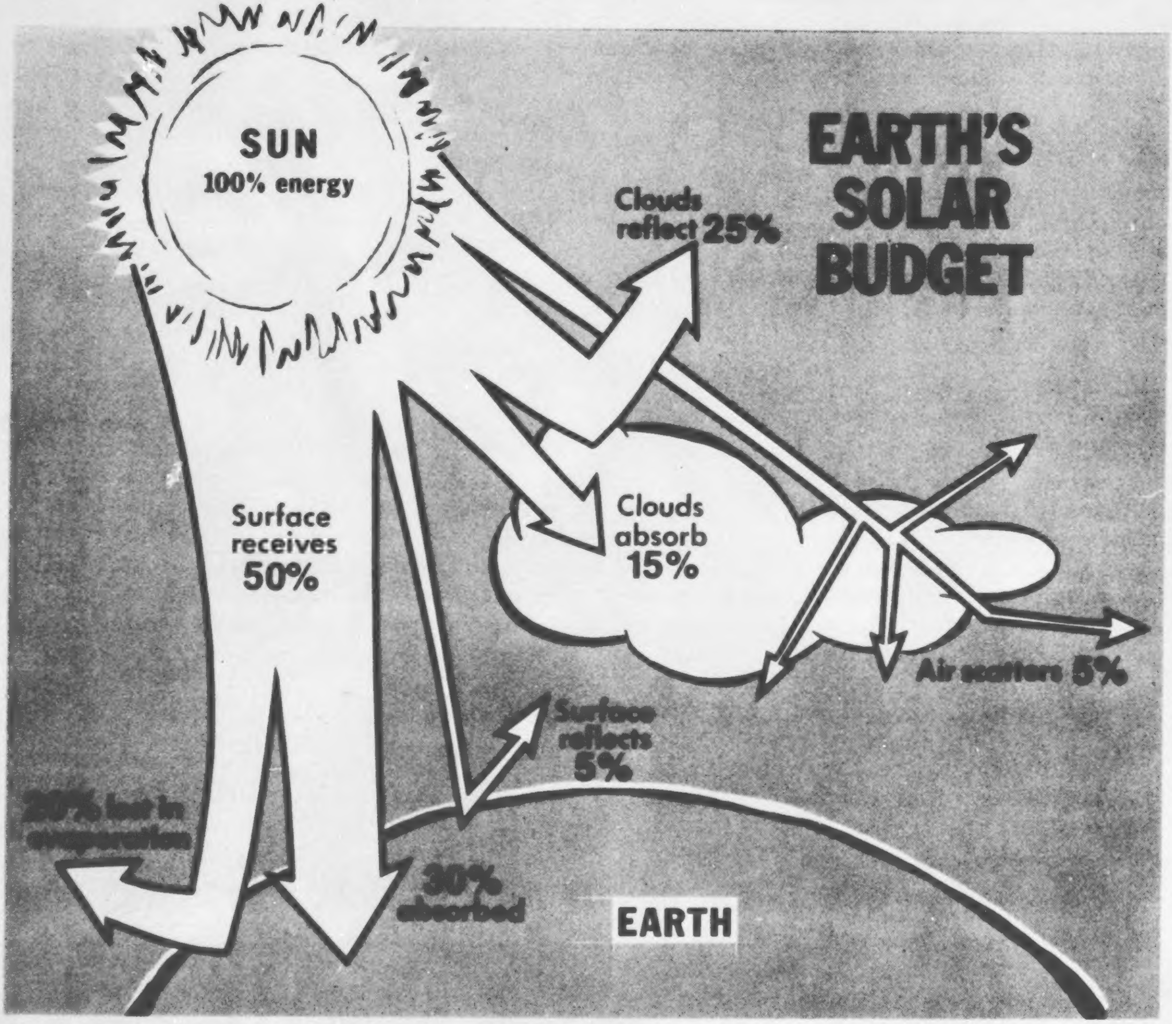
3. Like the sun, an ordinary incandescent lamp scatters light in all directions. Unlike the sun, a reflector lamp (including heat lamp) directs its energy to a limited area.

The final day of this activity may be spent making graphs and discussing the implications of the data and the usefulness and limitations of the models used.

Results are expected to show that covered models heat more slowly than uncovered ones during the first minutes, but the covered ones get warmer after that and stay warmer longer. Soil-lined models warm more quickly than water-covered ones, but also cool faster.

If at all possible, plan to take the class to a working greenhouse at this time. Arrange in advance for the owner-operator to be prepared to discuss heat and humidity control, heat storage systems, fuel requirements, uses of the shelter and kinds of plants that thrive in a greenhouse, etc.

Consider doing Extensions 1 and 2 by having groups of students assigned to various alternatives. Plan a data-sharing and discussion follow-up. You may ask the language arts teachers to assign Extension 4 and the home economics or industrial arts teachers to consider doing Extension 3 while students are involved with this activity.


EARTH'S SOLAR BUDGET
SUN
100% energy
Clouds reflect 25%
Clouds absorb 15%
Surface receives 50%
Air scatters 5%
Surface reflects 5%
20% lost in evaporation
30% absorbed
EARTH

Mini-Drum Wall

Background:

Solar-heated buildings are subject to wide swings in temperature. They heat up rapidly during sunlit hours but cool off quickly after dark. To moderate the heat flow, mass storage has been incorporated into many passive solar structures.

To perform effectively, a storage system must incorporate significant weight (the "mass") of some material that absorbs heat slowly during exposure to light and then releases its stored heat slowly to the interior space at night. This thermal flywheel or time-lag effect is most important for keeping indoor temperatures lower by day and higher by night than in similar buildings without mass storage.

Some examples of heat storage systems incorporated into passive solar homes are Trombe walls; concrete slab floors over beds of rock or water bags; water-filled columns in or near the glazed south wall; adobe window seats; and drum walls.

Introduction:

Water is an especially valuable heat sponge. It is cheap. It is available everywhere that people live. It is reusable indefinitely. It has both a high specific heat and a high density; together these physical attributes give water the highest heat capacity of any substance at standard temperature and pressure. But its liquid form makes containers necessary.

Steve Baer of Corrales, NM, has built a prototype passive solar home using 55 gallon drums for mass storage of water. A horizontal stack of drums in a metal support frame stands behind glazed south walls fitted with insulating covers that are raised and lowered daily.

Other individual examples of mass storage systems based on water as the heat sponge are use of one-gallon to five-gallon plastic jugs or five and a half gallon sono-buoy cases massed together near a glazed southern exposure; columns made of steel culverts or fiberglass cylinders; roof ponds; and water-filled hoses embedded in a supporting wall of masonry.

Objective:

In the following activity, you will model a mini-drum wall, record its effect on heat flow within an enclosed space, and measure its heat storage capacity over a limited time.

Materials:

2 lb. coffee can with plastic lid
Two flat-sided, cheap styrofoam "cooler" containers designed to hold two 6-packs of canned pop are a convenient size, with interior dimensions about 17.5 cm x 25 cm x 29 cm (cost: $1.50 in 1980)
Heaviest plastic food wrap or clear polyethylene "storm window" sheeting
Four small thermometers (AS & E type) or three standard lab models
Masking tape
Black paint, brush, for shiny cans only
Aluminum foil: optional

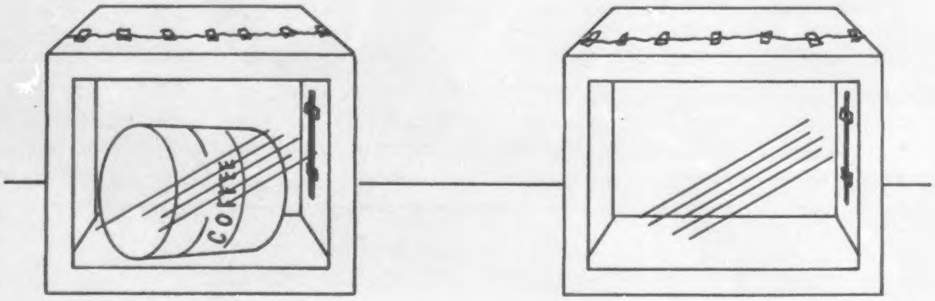
Directions:

If your coffee can is already stamped with a dark red or dark blue background color, no preparation is necessary. However, if it had a paper label and is now silvery-colored on the exterior, paint it flat black.

Measure out enough water to nearly fill the coffee can (Two quarts or two liters should do it). Record both the volume of water used and its temperature. If you have a small AS & E type thermometer, leave one in the "drum". Then secure the plastic lid.

Lay each styrofoam container lengthwise on its flat size, lid off. Tape a thermometer to the inside wall of each where it is out of direct sunlight but where it can be conveniently seen. Tape another thermometer to the outside rear of one of the containers to keep track of the ambient air temperature.

Lay the coffee can "drum" inside one of the styrofoam containers (label it "A"). Then cover the open side with clear plastic. Secure it across the edges with masking tape. Also cover the matching styrofoam container "B" with plastic.



Position both containers the same way, allowing sunlight to strike the plastic covers. (If you want to add an aluminum foil square as a reflector, laying it on the ground in front of each model, cut two identical squares.) Record air temperatures within both models and on the outside. Expose both models to the Sun for 30 minutes. Then record thermometer readings again, including the one in the drum. Subtract the first readings from the second ones to find the difference. Then estimate how much heat your mini-drum wall collected, following instructions on the data sheet.

Questions:

1. In your own words, describe the effect of the mini-drum wall on its air space.

2. How could the drum wall be improved to collect heat better?

3. How could the stored heat be made to last longer?

4. What materials (other than water) could have been used effectively in the drum to collect and store heat?

5. What materials would not effectively store heat?

6. Why was a "control" model used in this experiment?

7. How is a drum wall collector different from an "active" solar collector?

Resources:

Kroner, W. and Haviland, D. Passive Design Ideas for the Energy Conscious Consumer, free booklet from National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, MD 20850.

Magazines featuring contemporary homes. Consult Reader's Guide to Periodical Literature under topic headings: Conservation, Energy-Efficient Houses, Houses, Solar Architecture, Solar Energy.

Mazria, Edward. The Passive Solar Energy Book. Rodale Press: Emmaus, PA, 1979, $10.95.

Wright, David. Natural Solar Architecture, A Passive Primer. New York: Van Nostrand Reinhold Company, 1978, $7.95.

Extended Activities:

1. Use a third model, enclosing a water-filled shiny can the same size as the dark one. Follow the same procedure as with models "A" and "B". Compare results.

2. If time permits and/or you can do the testing over a weekend, expose the models for a longer period of time, two to eight hours, recording inside and

outside temperatures every hour. (Will it be necessary to check water temperature every time?) Then cover each unit tightly with its original styrofoam lid and let it sit undisturbed for a comparable length of time. Afterwards open each, quickly read thermometers and record results. Graph your data. Which is warmer? Why? Which container had more heat to begin with?

From your results, can you estimate how much stored warm water would be needed to keep a 20 ft. x 12 ft. x 8 ft. room comfortable overnight? If not, list the kinds of information you would need in order to make such an appraisal.

3. Draw a picture or outline a floor plan for a new home incorporating drum walls.

4. Write a list of design restrictions drumwalls impose and any other drawbacks to this method of heat storage. Make a second list of drumwall advantages.

5. Can you imagine portable solar heat storage, some kind of mass storage system that could be placed outdoors for full exposure to the sunshine yet be brought indoors (or its heat piped through) at night?

   If you can develop this idea, draw a picture or write some paragraphs describing your system. You may consult the librarian for reference suggestions on new heating systems for homes and other buildings. Can you find any examples now constructed and working?

6. Find out ways and means to keep drumwalls from rusting.

Name ______________________________

Data Sheet: Mini-Drum Wall

Amount of water used: __________ ml or ____________ g

__________ oz. or ____________ lbs.

Time	Outside Temperature	Air "A" Temperature	Water "A" Temperature	Air "B" Temperature
Start:				
Finish:				
Difference:				

1. To figure heat gain in BTU's, multiply

______________ x ______________ = ______________ BTU's
lbs. H_2O Difference °F

2. For heat gain in calories, multiply

______________ x ______________ = ______________ calories
g H_2O Difference °C

3. What is the volume (interior space) of your styrofoam model?

______________ x ______________ x ______________ = ______________ (units^3)
length width depth

4. What is the volume of the coffee can?

__________ x __________ x ____________ x ____________ = __________ (units^3)
length lid radius lid radius pi

5. Calculate what percentage of interior space is occupied by the mini-drum wall.

____________________ ÷ ______________________ x 100% = ___________________%
Volume of can Volume of model

175

Teacher's Guide to Mini Drum Wall

Objective:

This activity can provide students with an opportunity to see how a mass storage system may moderate heat gain and heat loss in a building, to notice differences in heat capacity of some materials, and provide practice in quantifying heat.

Time Required:

At least two 50-minute class periods are needed: one for introduction to thermal storage ideas and for preparation of the materials; one for data collection and calculations. Questions and extended activities (optional) may be done as outside assignments or during class time.

Advance Preparation--Materials:

Collect styrofoam boxes, clear plastic sheeting, coffee cans. Two pound cans are suggested as an effective match for the cooler size specified. You could use smaller cans but more of them, or you could select another size of styrofoam cooler. If you do, try to maintain a ratio of at least one volume of water to every ten volumes of air.

Get flat black paint and brushes if necessary. Cans that are blue or red color-painted metal need no extra paint.

Aluminum foil (optional, but it does boost the amount of sunlight entering the enclosure) should be on hand.

Hand calculators are desirable, optional time-savers on the volume calculations in particular.

Plastic jugs of tap water should be set aside for filling drum walls. Set them out a day ahead of time so that the water temperature is at equilibrium with the ambient air and any excessive aeration escapes. Chill a 16 oz. bottle of pop the day before the experiment.

Procedural Notes:

Students measure temperature and mass of the material, but must calculate heat gain by multiplying those two variables. Either BTU's or calories can be conveniently used as energy units. BTU's, based on the Fahrenheit scale, are commonly quoted when the subject is energy consumption of the whole country or the heating capacity of a furnace. However, calories may be a more familiar term to diet-conscious students. Remind them that calories, based on the Celsius temperature scale, are 1,000 times smaller than a kilocalorie or food calorie.

Give students advance practice calculating BTU's. Use the half-hour waiting time that the models sit in the Sun. Heat up a beaker of water for a few minutes. BTU's gained = pounds of water x($^\circ F_2 - {}^\circ F_1$) or calories gained = grams of water x ($^\circ C_2 - {}^\circ C_1$). Also remove a 16 oz. bottle of cold pop from the refrigerator, immediately record the temperature of the pop, and then let it warm up (may be speeded somewhat by warm hands clutching the bottle). Again calculate BTU's and/or calories.

It is not necessary to actually weigh the water in any of these activities. Careful measurement of volume is sufficient because water's weight/volume relationship is predictable. Under normal conditions, the mass of 1 ml of water is 1 g and the mass of 16 fl. oz. of water is 1 pd.

Results:

Air and water in the drum wall model will appear to heat more slowly than does the all-air model where temperature rises rapidly. If time permits measurement of the cooling rate, the drum wall model will also cool more slowly. The difference in response to heat by various materials is noteworthy.

Some students may prefer to use an empty (air-filled) can for the control "B". If they do, the air space will heat even more rapidly at first, but it will cool very rapidly also.

Drum water and air within the same enclosure will show the same temperature throughout. Equilibrium is maintained between the collector can and its immediate surroundings. So taking a separate record of the water temperature inside the drum, especially during an extended activity where data is collected over several hours, is unnecessary. Because of its much greater mass, the water holds much more heat at any given temperature than air does. But the thermometers do not measure total heat; they measure average heat only.

Sample figures for an actual test follow:

Time/Temperature (degrees Fahrenheit)

"Drumwall" models	1:00 pm	1:30	2:00	3:15	3:45	4:30	5:00
1. Black can, air-filled	66	114	112	100	94	82	78
2. Black can, water-filled	66	74	80	88	92	94	90
3. Black can, paraffin-filled	66	90	90	92	90	88	84
4. Outside air	66	66	66	66	66	66	65

If you are curious about the relative heat capacity of air and water compared to other materials, the following data is interesting.

Specific Heat and Heat Capacity of Selected Materials*

Material	Specific Heat (BTU/lb. per °F)	Density (lbs./ft.^{3})	Heat Capacity (BTU/ft.^{3} per °F)
Air	0.24	0.075	0.018
Brick	0.20	123.	25.
Concrete	0.156	144.	22.
Oak Wood	0.57	47.	26.8
Polyurethane (Expanded)	0.38	1.5	0.57
Steel	0.12	489.	59.
Water	1.0	62.4	62.4
Wool Fabric	0.32	6.9	2.2

**Data from American Society of Heating, Refrigerating, and Air Conditioning Engineers, ASHRAE Handbook of Fundamentals, New York: ASHRAE, 1972.*

178

A Simple Solar Oven

Objective:

To demonstrate the use of direct solar energy to warm air in an enclosed space and to cook foods.

Background:

Cooking with the Sun is a way to show that light energy can become useful heat energy. But time, energy, and materials must be properly invested in order to make use of "free" solar energy. This incoming energy is spread out, not concentrated. And its rays seem to change direction as our Spaceship Earth circles the Sun. Still, solar can be used effectively for many jobs, including slow-cooking of meat and potatoes; heating houses; and heating water. This model oven will give you chances to do some solar heating and solar cooking on the next sunny day.

Materials:

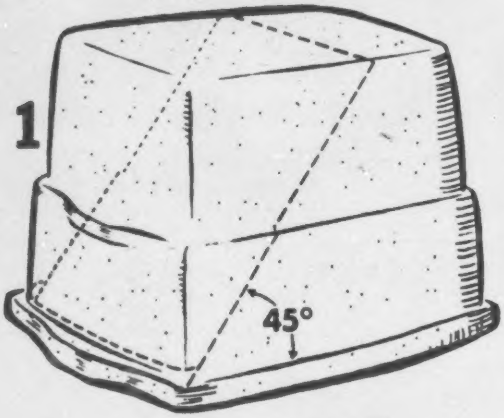
Rectangular styrofoam cooler with well-fit lid
Oven thermometer
Duct tape and scissors
Jigsaw, electric knife or craft knife
Double-strength glass pre-cut to fit over your cooler opening
Asbestos sheeting
Aluminum broiler foil
Protractor, ballpoint pen
Rubber cement
Cardboard, corrugated boxes, sheet aluminum or any other reflector material available

Directions:

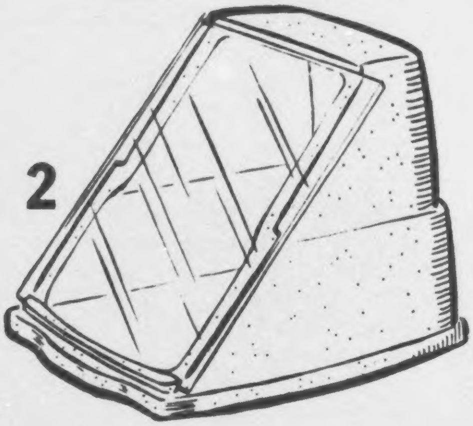
Set the cooler upside down on its lid. Using the protractor and ballpoint pen, mark the 45° diagonal from the bottom "lid" edge upward, as in diagram 1.

Cut as indicated by the dotted line, diagram 1, leaving slots for the glass window to rest in. Line the inside with asbestos sheeting first and then aluminum broiler foil. Cement the lining in place. You may also paint the inside foil lining with high temperature black barbecue finish paint.

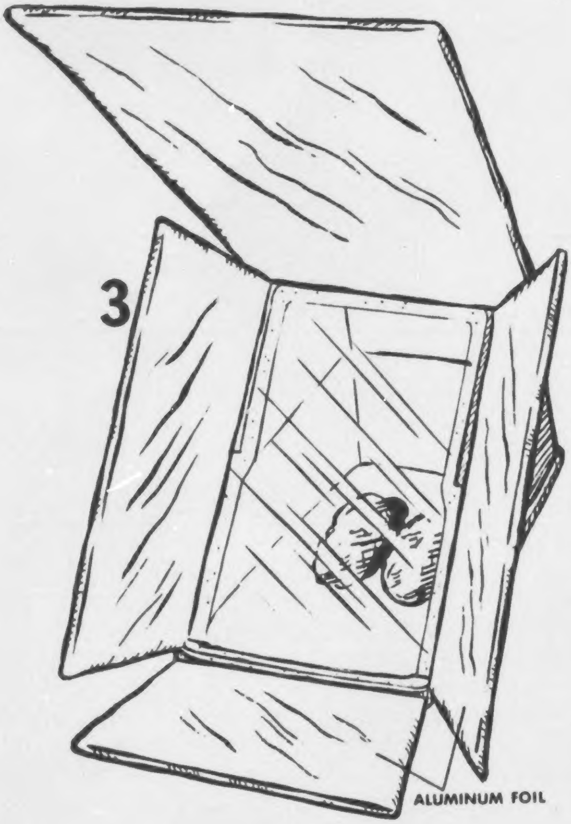
1



2



3



Measure the opening for glass and buy a piece that will cover it and the styrofoam edges completely (diagram 2). Tape the glass securely in place and cover all edges with aluminized duct tape.

Make reflectors from cardboard or pieces or corrugated boxes covered with aluminum foil. Hinge two of them and attach with duct tape to the sides of the oven. Support the backs with hanger wire if necessary. Lay one reflector on the ground in front of the oven and angle another one over the top. (See diagram 3.) You can see spots of light on the glass when the foiled panels are positioned most effectively.

Position your solar oven outdoors with the glass directly facing the Sun. You have the correct position when the shadow of the oven lies directly behind it, not more to one side than the other. Every 15-20 minutes you will have to move the oven slightly to keep it oriented to the Sun.

Lift your oven off its base (formerly the lid of the cooler) to put in an oven thermometer and whatever food you want to bake slowly. Potatoes are shown in the diagram. Cookies can be baked on a cookie sheet or pie tin.

Questions:

1. What was the highest temperature recorded in your oven?

2. How could you improve efficiency of the oven?

3. Can you expect to get the same oven temperature almost any day?

4. What advantages are there to using portable solar ovens?

5. What disadvantages or limitations to the use of solar ovens have you thought about?

6. If you had only a solar oven for cooking, how would your diet change?

7. List as many consequences of widespread use of solar ovens as you can foresee.

Extensions:

You may also want to use your "oven" (with or without reflectors) as a model of a passive solar home. Put the thermometer inside and test its heat gain outdoors on a cool day when home or school is made comfortable by use of its furnace or boiler.

Does a ground reflector help? Is the angle of the glass an advantage or disadvantage? (Change it by propping the oven higher or lower on one end.)

What effect does shading have on heat gain? (Make a cardboard "roof" extension to shelter the glass.)

Keep in mind that a house does not ordinarily move on its site (although innovative pod-like homes that turn on a pedestal have been built). Therefore storage of some of the heat gained by your "house-oven" during peak suntime for release at night is important to any passive solar design.

After you have recorded the temperature changes in your empty model over a period of several consecutive hours--from noon to sunset, for example--change the conditions the next day by adding one of the following: some rocks, a can of water, a can of paraffin, or a jar of eutectic salts to the interior of your construction. Record the temperature changes during the same hours as before. Compare results.

Or, if several classmates have made identical models, you may be able to test various materials simultaneously. Decide how much material each should use to keep amounts comparable. Then record temperature changes over several hours.

Which material stored heat best? Which material would be easiest to incorporate into a new house plan?

Try to find information on existing buildings using any one of the heat storage materials you tested and write a description of it to present in class.

Teacher's Guide to A Simple Solar Oven

Cooking with the Sun has been one of the more popular projects attempted by solar enthusiasts. Hot dog cookers with a spit and curved reflector are easy to make. Umbrellas lined with mylar have been used to focus solar heat on a teakettle or rice pot. Curved reflectors made of aluminum also can help concentrate light onto food enclosed in black cans or glass-windowed boxes. Fresnel lenses have been used to produce intense heat, and oven plans using one are available for $.75 from Edmund Scientific Co., 1888 Edscorp Building, Barrington, NJ, 08007.

A durable oven made of sheet aluminum and plywood is described in detail, with constructon diagrams, in Practical Sun Power by Rankins & Wilson, from Lorien House (publisher), P.O. Box 1112, Black Mountain, NC, 28711, for approximately $4. This model would be appropriate for industrial arts students to build and would last longer than the model described here. However, it would require a greater initial investment of time and materials to complete it.

The styrofoam box model suggested here is inexpensive to construct and can be used as a "model house" as well as a solar oven (with minor modifications). Turning the "lid" into a "base" eliminates some cutting and fitting. Most materials are readily available and can be worked without special tools. To prevent out-gassing of the styrofoam into the oven, it is important to cover the styrofoam with asbestos sheeting (comes in 24" wide rolls at the hardware store and is very inexpensive--$.25 worth should line an oven this size). This, in turn, is covered with aluminum foil. Less critical is the decision whether or not to paint the interior black. If you do, use a black barbecue finish made to stand heat. There was no noticeable difference in temperatures recorded between bright foil-lined and painted-foil-lined models that this author built. Differences between single and double panes of glass were also small. Double-strength glass is recommended, however, as less likely to crack under heat. When the oven was empty (full of air, as in a house) then a double-paned glass model heated 10-15°F hotter than a single-paned one. When water was to be heated (as in a rice casserole, or potatoes or meat which are three-fourths water themselves), the single-paned model cooked faster.

Simple flat aluminum foil reflectors, on the other hand, improved performance considerably, raising the interior temperature of a double-glazed model by 40°F in 15 minutes on a September afternoon. Mirrors or curved aluminum reflectors may improve performance even more.

The main problem with the reflectors as described is wind. Unless reflectors are weighty, every breeze can change their position and reduce their effectiveness. Wind chills the oven, too, suggesting the need for careful sealing and more insulation if the oven is to be used often.

One of the main objections to solar cooking in fuel-short Third World countries is that the ovens work best around noon. This is not the traditional time for a cooked meal. Daylight hours are for working, marketing, schooling and any other away-from-home activities. Evening is the time for socializing over dinner, but sunlight is not available then. . . . Solar ovens also need adjustment (about every 20 minutes at our latitude) or turning to keep the glass front in direct line with the incoming sunlight.

The low heat (280°-300°) developed in the model oven described is suitable for baking potatoes (2-3 hours, depending on size) or slow-roasting meat or heating casserole dishes. Cookie dough would be a good choice for an edible project that can be baked during class time.

Let's Make a Solarimeter

Introduction:

While the photoelectric effect has been known for almost a century, the use of sunlight for electrical generation is a recent application of it. A solar cell and milliammeter are the key components of a simple solarimeter that provides a quick method for determining the intensity of the sun's radiation.

List of Materials:*

D. C. milliammeter 3" scale - 150 M.A.
Solar cell 2 1/8" diameter, 400 M.A., 0.45 v
Resistor 3Ω , 1/2 watt carbon
2 pieces of k/2" masonite 2 cm x 7 cm
Stranded insulated wire (any small diameter)
Tape, glue

Directions:

1. Drill two small holes (just large enough for thin insulated wire) in the back edge of the top cover of the plastic case in which the cell is packaged.

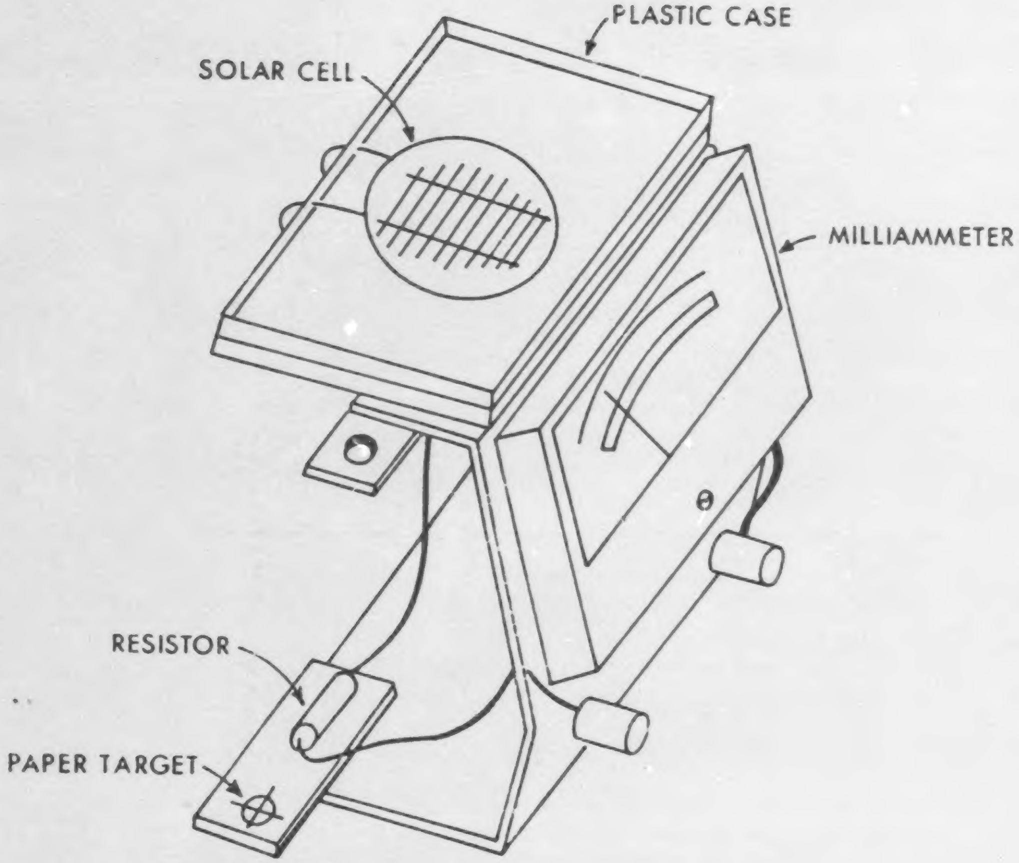
2. Tape the plastic case to the meter frame.

3. Drill a 1/4" hole in the sighting strip before cementing it in place.

4. Solder one lead of the resistor to the short piece of wire. Attach the other lead of the resistor to the wire (negative) from the solar cell. Solder the permanent setup (or use a screw and nut for easy disassembly of the cell).

5. Solar Cell--solder leads of thin stranded wire to the cell. Attach the lead from the backside of the cell to the positive (red) terminal of the D.C. milliammeter; attach the lead from the top side of the cell to the negative (black) terminal of the milliammeter.

**Materials list and construction directions are from the DOE-sponsored Solar Energy Education Project of the New York State Education Department, Albany, NY.*



6. By merely disconnecting the leads from the solar cell to the meter, the meter may be used as a milliammeter.

7. Cement small strips of masonite (or wood) to inside top and bottom flange of meter frame. Let 2 cm of ends of each overhang frame. Glue white paper with inked-on target pattern on bottom piece. These should be aligned so that a beam of light passing through the hole in the top piece strikes the target perpendicular to the plane of the solar cell.

8. The exact size of the resistor will depend on the characteristics of meter and solar cell used. The purpose is to reduce the current output of the cell, under maximum energy conditions, to nearly full scale value of the meter. A rough approximation of the size of the resistor in ohms can be found by using the expression:

$$R = \frac{V_{sc}}{I_{sc} - I_{fs}}$$ where V_{sc} = rated output

voltage of cell, I_{sc} = rated current (amperes) of cell, and I_{fs} = full scale value (amperes) of milliammeter.

Things to Do:

1. Use your solarimeter to measure variations in solar radiation over a period of time. Take one or two readings outdoors on every class day for a week. Record your readings as well as comments on the absence or presence of clouds, other weather conditions, and ambient temperature. If your daily readings are not consistent, consider reasons why not.

   A month or two later, repeat your use of the solarimeter outdoors, over a week's time. Are results comparable to the first set of data? Why or why not?

2. Can artificial light also generate electricity? Try your solarimeter under a 100 watt bulb; a 40 watt fluorescent tube; a sun-lamp.*

3. How practical are solar cells for production of electricity? Look for current articles in Popular Science, Popular Mechanics, Science News, or other publications for the most recent estimates of their cost per kilowatt-hour. The Readers' Guide to Periodical Literature will give you references on this subject.

   a. Find out the advantages and disadvantages of solar cells for electrical generation.

   b. Read about Stanford Ovshinsky and his ideas for better solar cells.

**One important point to note about solar cells is that they only change part of the light that they absorb into electricity. This means that solar cells cannot power artificial lights perpetually because each conversion will be weaker than the one before it.*

Teacher's Guide to Let's Make a Solarimeter

Background Information:

Knowing the amount of energy received on a given area at the Earth's suface is fundamental to solar energy design. This energy arrives after passing through layers of atmosphere where different amounts of reflection, absorption, and transmission occur depending upon the wavelength of the incident radiation and the composition of the atmospheric layer. Part of this energy arriving is in the form of direct rays (ultra-violet - 9%, visible light - 41%, and infrared - 50%) from the Sun. The rest is indirect radiation which has been reflected or scattered by small particles, droplets of water, and molecules. The exact amount of each varies with Sun position and atmospheric conditions such as cloud cover, humidity, size and kind of dust particles, size of water particles, etc. On clear, sunny days the direct energy received may be as high as 90%; on cloudy days nearly all the energy may be indirect.

When this energy arrives at the surface, two things occur; part is reflected, and part is absorbed. Various instruments may be used to measure this energy. For example, the absorbed energy may produce a temperature rise. Thus a thermometer might be used as an indicator of energy absorption.

Another effect of radiant energy falling upon the surface of certain metals is the release of electrons, the photo-electric effect. The solar cell is a device that makes use of this effect. As the incident light intensity increases, a greater flow of electrons occurs through a circuit. The amount of current flowing can be used as an indicator of the energy received.

It is very important to remember that the amount of energy measured by any instrument is not necessarily the total amount of energy received. Most instruments do not measure reflected or transmitted energy. They only respond to the energy absorbed by the instrument.

The response of a solar cell is complex in that the cell is not equally sensitive to all wavelengths of incident radiation. In fact, it doesn't respond at all to the longer wavelengths. It also has a relatively low efficiency in converting radiant energy to electrical energy. Nevertheless it makes a very convenient, easy-to-use instrument when used in conjunction with a milliammeter. Such an instrument is called a solarimeter or pyranometer.

Careful comparisons of locally obtained data with published data for similar latitude and atmospheric conditions should permit the calibration of a homebuilt solarimeter. Direct calibration with commercial models may be arranged by contacting persons having access to these. Many colleges or universities have commercially built solarimeters available as do various weather stations, environmental agencies, and private corporations involved in solar energy research.

Expected Results:

Meter readings inside the building will be very low, almost zero.

Maximum readings will result when solar cell is held at right angles to the Sun's rays or a sun lamp (angle of incidence = 0°). Readings will be lower when the cell is in a horizontal position.

If data is taken throughout the year, the highest "clear day" values (with photocell held perpendicular to the sun's rays) will be observed in winter, not summer. One reason for this is that there is less moisture in the atmosphere at that time, and water vapor is the main interference for incoming solar energy. The Earth is also a little closer to the sun in January than in July.

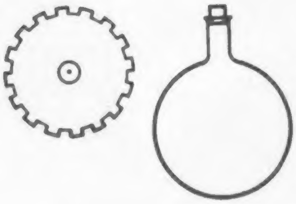
Precautions:

Warn students against looking directly at the Sun.

Explain that the equipment is fragile and must be handled with care.

Extensions:

Additional activities using a solarimeter are described in Solar Energy Project Activities: Chemistry and Physics available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402, Stock No. 061-000-00229-4, $2.20.



A Solar Still

Objective:

To demonstrate a practical use of solar energy.

Materials:

Glass bowl or large beaker
Table salt
Plastic wrap
Drinking glass or small beaker
Marbles
Newspapers

Procedure:

1. Prepare salt water using 3.5 g table salt for every liter of water.

2. Wash and dry marbles so that they are clean.

3. Organize the materials as shown in the diagram. Put some marbles in the beaker to keep it from turning over. Put the plastic food wrap loosely around the top. Secure the edges with tape or a rubber band. Then put one marble on the wrap so that it dips significantly over the small beaker.

4. Put the still on newspapers (for insulation) on the ground in direct sunlight. Leave it undisturbed for an hour or more. You can leave it overnight and reclaim it 24 hours later if you have a quiet location for it.

Questions:

1. Notice the appearance of the plastic cover. What has happened?

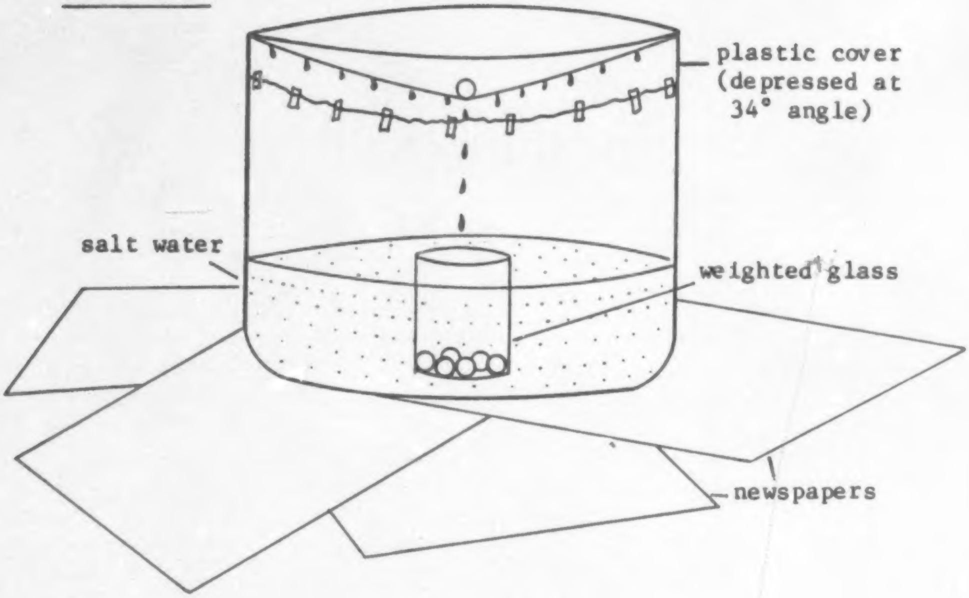
2. Remove the cover and examine its underside. Put some of the drops on your finger and taste it. It tastes like ____________.

3. Remove the glass. Carefully take out the marbles (if you used them). Examine the remaining contents.

    a. What is it?

    b. What evidence identifies it?

Solar Still


plastic cover
(depressed at
34° angle)
salt water
weighted glass
newspapers

4. How did the "new" material get into the glass? Was work done?

5. What does distillation mean?

Extended Activity:

Using library resources, find out about water desalinization (taking salt out) projects around the world. Do any of them use the Sun? Where in the world are people most interested in getting fresh water from salt water? Why?

190

Teacher's Guide to A Solar Still

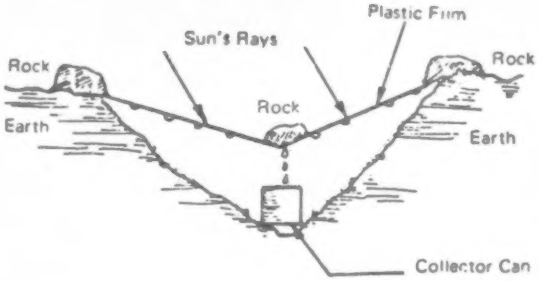
Evaporation of the salt water doesn't happen in a few minutes, so it is not reasonable to expect results in a single class period. Try to find a warm and sunny location where the still may sit for at least 24 hours. Eventually a mist of fresh water will collect on the surface of the plastic and some will drip into the glass.

You could, of course, use a sunlamp to warm the still and get results much more quickly. Using fossil fuel to power the lamp means starting with much more concentrated power and thereby compressing time for a "now" generation. This is not recommended because students get a false impression of easy, instant results instead of pacing their expectations to a natural cycle.

An industrial arts class or senior high science students may like to make a more functional and durable still. Measurements and diagrams for construction of one are included in Practical Sun Power by Rankins and Wilson, Lorien House, P.O. Box 1112, Black Mountain, NC 28711, $4.

If an area of the schoolyard is available for digging a shallow pit 30 to 40 cm deep, students may construct a basic survival still using a clean jar, beaker, or can for the collector and a piece of plastic storm window sheeting for a cover. Use rocks, bricks, or scrap lumber to hold down the perimeter of the plastic film. Put another small rock on the film over the collector, depressing the center of the film about 30-35° from ground level. Water tends to cling to plastic (more readily than to glass) so a relatively steep incline is important to get droplets rolling.

Mark the hole so no one will accidently step into it. Let the still sit undistrubed for two to 24 hours. Then remove the can and refill the hole. Take the fluid collected to the classroom for identification. Students may want to make a slide with a drop of distillate and check for presence of bacteria, or try to start a bacterial colony on agar with it.



Survival Still

A Classroom Savonius Windmill*

Introduction:

The Savonius or S-rotor windmill was introduced to the United States in 1924. The powershaft is located in the vertical plane rather than horizontally as in the traditional bladed Stuart windmill. This has several benefits. The windmill does not need a wind direction seeking vane since it doesn't matter from which direction the wind is blowing. Also, power is available at the base of the mill rather than at the top of the tower. The Savonius mill is also less easily damaged by high winds than the traditional windmill.

A simplified Savonius windmill may be constructed for your classroom without too much difficulty. The model is approximately three feet tall which makes it portable and easy to store and yet it is large enough to actually generate electricity when coupled with a small permanent magnet electric motor operated as a generator.

Materials:

To construct the model, you will need the following materials:

Three two-pound coffee cans or the equivalent
1/4 inch diameter threaded rod, three feet long
Six 1/4 inch diameter nuts
Two roller skate wheels with a 1/4 inch inside diameter
Scrap masonite or thin plywood for end caps
Scrap pine lumber or plywood for the support frame
Epoxy cement

Obtain all of the materials before you begin construction. You may find it necessary to make substitutions in materials and/or dimensions. Plan ahead and you won't get any unexpected surprises.

Model directions provided by William G. Hoffman, Capt. Nathan Hale School, Coventry, CT, 06238
**Reprinted from Connecticut Journal of Science Education, Vol. 14 (2).*

Procedure:

1. Cut both ends out of three coffee cans. Carefully cut the cans in half lengthwise so that you end up with two equal sized trough-shaped pieces from each can. Cover the sharp edges with adhesive tape to lessen the possibility of a cut.

2. Next fabricate the four end caps of thin plywood or masonite, 1/8" or 1/4" thick will be adequate. The diameter of the end caps should be twice the diameter of the cans you used plus 1". These end caps should be round and must have a 1/4" diameter hold drilled in the exact center. Draw a straight line through the center of each end cap with a pencil to assist you in positioning the rotor blades on the end caps.

3. Assemble two can halves to an end cap in the following manner to form a rotor subassembly. Use epoxy cement mixed in accordance with the package instructions to glue the rotor blades in place (Fig. 1).

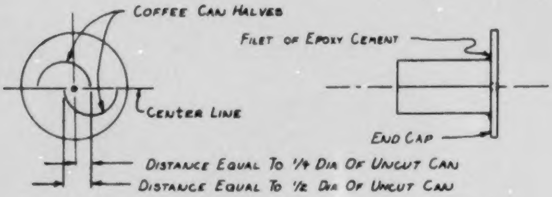

COFFEE CAN HALVED
FILET OF EPOXY CEMENT
CENTER LINE
END CAP
DISTANCE EQUAL TO 1/4 DIA OF UNCUT CAN
DISTANCE EQUAL TO 1/2 DIA OF UNCUT CAN

Fig. 1.

4. Make a total of three rotor subassemblies as shown in step 3.

5. Join the three rotor subassemblies and the fourth end cap as shown in Fig. 2 by passing the three foot threaded rod through the center hold of each end cap. Make sure that the center line of each end cap is oriented 60° away from the one below it. Epoxy each rotor subassembly and the fourth end cap to the one next to it and tighten the 1/4" nuts to hold everything together until the epoxy cement dries.

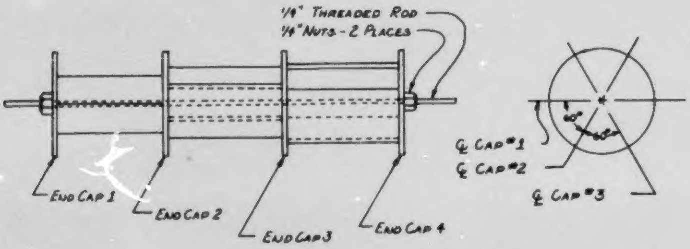

1/4" THREADED ROD
1/4" NUTS - 2 PLACES
60°
60°
℄ CAP #1
℄ CAP #2
℄ CAP #3
END CAP 1
END CAP 2
END CAP 3
END CAP 4

Fig. 2.

6. Install the bearings (roller skate wheels) as shown. Use a 1/4" nut at each end of the bearing to hold it in place and lock it to the rotor shaft. Tighten the nuts snugly (Fig.3).

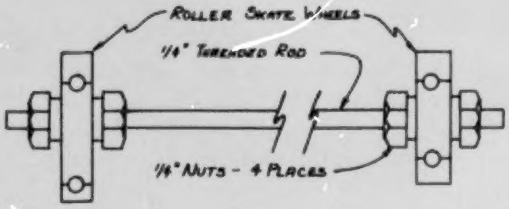

Roller Skate Wheels
1/4" Threaded Rod
1/4" Nuts - 4 Places

Fig. 3.

7. Balance the rotor assembly by placing it horizontally supported on its bearings (for instance, between two desks) and spin it by hand. When it stops spinning, mark the very bottom of one of the end caps with chalk. Repeat this procedure several times. If you find that one side always ends up on the bottom, you will have to lighten this side by removing material from the end caps. Do this gradually by filing, sanding, or scraping away the excess, carefully checking to assure that not too much material has been removed. When the rotor is correctly balanced it will stop in random positions when spun. This completes the rotor assembly.

8. Make a suitable framework that will allow you to mount the rotor in a vertical position supported by its bearings and free to turn in the wind. This framework may be constructed of scrap plywood or 3/4" lumber. A suggested configuration is shown in Fig. 4.

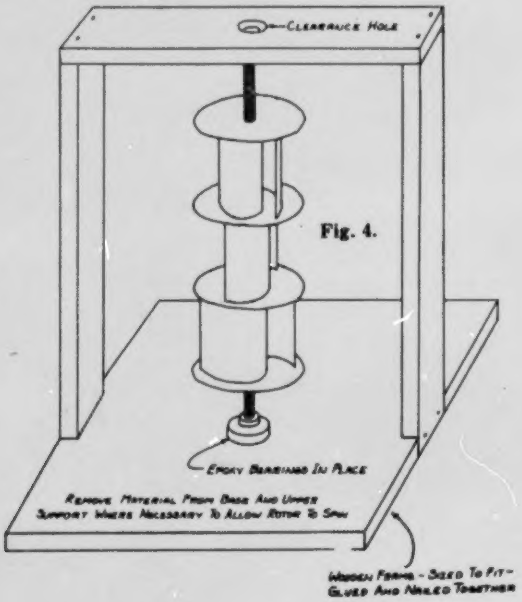

Clearance Hole
Epoxy Bearings In Place
Remove Material From Base And Upper Support Where Necessary To Allow Rotor To Spin
Wooden Frame - Sized To Fit - Glued And Nailed Together

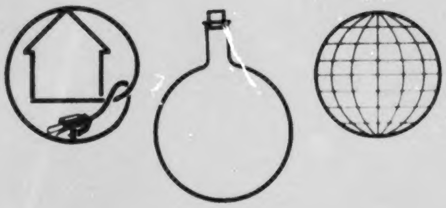
Fig. 4.

9. Epoxy the outer races (surfaces) of the bearings to the base and upper support. Make sure that the rotor is free to turn. You may have to remove some material from the base and upper support by drilling to allow clearance for the inner race of the bearing and 1/4" nuts on the end of the threaded rod.

Conclusion:

Take your masterpiece outside on a breezy day and see how well it works. If you are satisfied with its performance, you may attach a small 1 1/2 volt DC permanent magnet motor to the shaft by using pulleys and elastic band belts. When the motor is spun fast enough it will generate enough electricity to light a 1 1/2 volt light bulb.

Further information on the Savonius windmill may be obtained by referring to the Mother Earth News magazine and other periodicals, such as Popular Science, Popular Mechanics, and Mechanix Illustrated. Wind and Windspinners, by Michael A. Hackleman and David W. House, published by Peace Press, Culver City, CA, is a very comprehensive source of information on the Savonius type windmill.



Energy and Standard of Living

A Participative Demonstration

Americans are justifiably proud of having achieved a "high standard of living" and treasure a certain "quality of life." But a rapid rate of using mineral wealth may make us too dependent on certain resources that are limited in supply. The following simulation may suggest effects of depletion of fuel reserves on the standard of living to which we are accustomed. The primary objective is to show how closely related are the commonly accepted elements of comfortable living and the availability of underground petrochemical reserves.

Materials:

About 100 yards of colored string, cord, button thread, fishing line, or yarn
About 100 yards of white or natural string or cord or button thread (assorted scraps can be used, so long as there are two distinct types or colors available)
Paper for large name-tags, and pins to attach them
Marking pens

Procedure:

Ask each student to help define a "high standard of living" by making a short, personal list of the things (products, services) that he associates with a high standard of living. Then ask each student in turn to read off one of those items, trying not to repeat those previously mentioned. Write the students' suggestions for factors in a high standard of living on the chalkboard. Some likely suggestions will be "nice clothes, easy transportation, appliances, comfortable house, swimming pool, long vacations, trips, sports, television, radio, restaurants, sanitary services, medical care, gardens," etc.

After each person has contributed at least once, ask the class for any additions or combinations. When responses slow down, then consolidate items on the master list until the number of necessities for good living is the same as that of the people in the classroom.

Assign each student the "role" of a particular item (from the class list) necessary for a high standard of living. Take for yourself one saying "energy" or "fossil fuels" or "petroleum" or whatever equivalent was suggested by the students. Each person should label a large name tag (piece of paper) with his role-title and pin it on his clothing.

Ask students to arrange themselves in a circle and to use lengths of white string to connect themselves with any and all other elements of the good life on which they depend. Put yourself in the middle and ask students to connect to you a length of colored string if the product or service they represent requires your energy input. A rather complex web should emerge.

Next ask everyone to imagine that a serious shortage of fossil fuels occurs. Simulate the results by first removing all white connections between components that also have a colored string (dependency on fossil fuels). Leave the other white threads intact. Second, remove all colored strings. (Say that the fuel supply is so limited that only emergency needs can be met.) Have students with no connecting strings left leave the ring.

The resultant two-stage simplification of the web is dramatic. Make comparisons to social and ecological dependencies that involve us all.

Questions:

1. What hardships would the "simple life" of the remaining web (without abundant fossil fuels) impose on people?

2. What would be the advantages of a simpler life, less dependent on energy?

3. Would widespread solar power or fusion energy possibly rebuild the web entirely (based on some product and service items originally specified) if all fossil fuels were gone?

4. Can you describe a "high standard of living" without including the need for goods or services provided by fuels dug up from the Earth's surface? What would its basic elements be?

Life Without Electricity:
A Peace Corps Experience

Introduction:

After graduation from the University of Iowa, Jensy Patterson joined the Peace Corps in the summer of 1978. She was sent to Kenya, East Africa where she became one of four teachers staffing a 90-student Harambee high school. The rural village that is her home now lies in mountainous terrain near Lake Victoria and Kisii in western Kenya. The area has only two seasons, the rainy and the dry. Daytime temperatures do not change much throughout the year, but nights during the dry season can be chilly. Here are some of Jensy's comments on her new life without electricity, excerpts from a letter she wrote to a snowbound friend in Iowa:

The Letter:

Keroka, Kenya, January 22, 1979

For your own knowledge, I'll try to describe some of the energy uses here. Of course, there is no electricity. There is some in Kisii town which is about 12 miles away.

Everyone lives in small mud and thatched huts. The only permanent buildings around are the school and my house. Even the small dukas (shops) down the road are made of tin.

Firewood is commonly used if the dead wood can be found. (I came back one weekend to find many of my trees chopped down.) It's hard for these people on the top of the mountain and on the sides because the trees help prevent erosion, yet they need the wood for cooking and occasionally for warmth. They cook in their huts on the floor or in chiko--a small round metal container. It sits on the ground and is similar to our barbecue stoves. The old men in the market make them and sell them for about 15/= to 25/= ($2-$3).

December is also charcoal making month. All over the hills you can see smoke billowing. They chop the wood and cover it with dirt, leaving some small holes, and then light it to remove the impurities. After about 18 hours they have charcoal. This is sold for about 20/= ($ ____) for a large burlap bag. This is what is most commonly used in the chiko cookers. They use kerosene to light them. This is also used in their lanterns.

Candles are also used for light, but not often. (I do use them, but they are expensive here.) Kerosene costs about 11/= ($1.50) for five liters. I also use a pressure lamp which is about 600 candle power, but these are very expensive. Mine cost about 300/= ($43). I almost feel bad about having it, but figure the cost of my eyesight is worth a lot more than the impression these people will get of me having so many things.

A few, very few, wealthy people use a gas cooker. There are also pump stoves run on paraffin and some people use these, but I prefer the charcoal.

After awhile, all this becomes a way of life. I really enjoy not having electricity. Life is very simple without it. People usually go to bed early here too. 9:00 p.m. is "getting very late, madam!"

Kenyans depend on the sun for so much--time, drying clothes, crops. It seems the days are getting longer here too.

Of course there is no running water either. I'm the only one within several miles who has a rain tank. The school provided it, but it leaks and thus I too am dependent on the "river" (small stream actually) for my daily water needs. Because of my cooker I can warm my bath water but most either bathe in the river or out of a bucket; both are chilling experiences, believe me!

Because there are no street lights there is very little transport on the road after 6:30 - 7:00 p.m. The African's eyesight must not adapt too well to driving at night.

Torches (flashlights) are a part of every household. Batteries are very expensive. I have gone through so many. In physics I taught my kids that if you put the cells in the sun when they are weak, this exposure will repolarize them so that they can be used again. They were thrilled.

In all of Kenya there is only one "laundromat." It's in Nairobi and you can bet four of the six machines are always broken. Everyone does laundry by hand, then lays it on the grass to dry. I've learned to fold mine so they don't have too many wrinkles. There are charcoal irons though.

Of course, with no electricity there is no refrigeration. Many simply don't need it. My eggs last about three weeks and up on my hill my fresh butter will stay hard for two weeks. I'm extremely atypical though. No one else has the coolness I have.

There is milk in cartons I buy called UHT--it's ultra heated. Also margarine comes in a can and dried milk is popular. Many people enjoy the "sleeping milk" which is sour and curdled and kept in gourds. Kenyans think that the soured milk is very sweet and they simply can't understand why I don't like it. They use fresh milk only in tea.

Hope this gives you some picture of life without electricity. Cold sodas are unheard of as is beer. You get used to things!

As always,

Jensy

Teacher's Guide to Life Without Electricity: A Peace Corps Experience

There are many areas for discussion or for written question-and-answer responses suggested by this letter. Choose some that reflect your own interests and the subject matter of your course. Or ask a teacher from another discipline to participate in a wider ranging class discussion on ways and means of getting along on a low-energy budget.

Examples of questions you may use are:

1. What renewable sources of energy are mentioned in the letter?

   (Firewood and wood charcoal; sun; also students possibly may mention candles and gas which may be "renewable," depending on the raw material base for each. Candles can be made of beeswax or tallow, which are "renewable" or from paraffin, a non-renewable petroleum by-product. Natural gas, L.P. gas, or propane is associated with oil production from underground reservoirs and is not renewable. Methane or "biogas" from anaerobic digestion of organic wastes is renewable. In fact, the candles and gas to which Jensy refers are petroleum by-products and are therefore non-renewable.)

2. What non-renewable energy sources are mentioned in the letter?

   (Cooking gas, batteries, kerosene, paraffin, candles)

3. Which of the above energy sources did your grandparents use 40-50 years ago?

4. Which of the energy sources mentioned above do you use regularly now?

5. What do you think Jensy likes best about her low-energy-use situation?

6. What does she like least?

7. How has lack of electricity changed her living habits?

   (Note references to cooking and food storage; laundering; sleeping schedule; transportation.)

8. If you were to take Jensy's place in Kenya, what would present the greatest challenge to your present lifestyle?

9. What would be necessary for your survival in a remote Kenyan village? Would you have to take some articles from home with you?

10. Locate Kisii, Kenya on a map of Africa.

What is its latitude? (0.5° S)
What is its longitude? (nearly 35° E)
What is its elevation? (high plateau, mountainous terrain, more than a mile high)

11. What does the above information tell you about insolation (incoming solar radiation) in that part of Africa?

(Near the equator, solar insolation is maximum. The sun is directly overhead twice yearly and the lowest "winter" angle is comparable to the angle of the summer sun in Iowa. The high elevation means that the atmospheric blanket of air is thin. By day, less insolation is lost to atmospheric screening, but more heat is lost at night than would be true in the lowlands. Cool nights and snow on the highest peaks are possible.)

12. How does the local climate near Kisii moderate basic energy needs (compared to Iowa)?

(Little additional heat is needed for keeping people warm. Well-sealed homes that need artificial heating and cooling are not necessary for survival. However, heat for purifying water and milk is even more important for good health than here because tropical microorganisms are very numerous. Long growing seasons make long-term food storage less important than in Iowa, but heat is necessary for some forms of preservation--including tea production. Less clothing is needed for personal warmth. Transportation vehicles, where available, run more efficiently in warm climates than in cold ones. Animals require less food to maintain body temperature and growth rate than they do in more variable climates. Trees grow faster so, if replanted, replace firewood faster. Daylight hours are never much longer nor much shorter than 12 hours so opportunities for evening activities are very limited unless some other source of light is available, even at the peak of summer.)

13. How much does a large bagful of charcoal cost in western Kenya?

(On the first page of Jensy's letter it says charcoal costs 20/= ($___)
Clues to the dollar equivalence are

--that cookers cost 15/= to 25/= which is $2-$3.

If 15/= is $2, than 1/= is $\frac{2.00}{15}$ or 13 cents

If 25/= is $3, then 1/= is $\frac{25}{3.00}$ or 12 cents

201

--that kerosene costs 11/= or $1.50,

so 1/= is $\frac{1.50}{11}$ or 13 1/2 cents

--that her lamp cost 300/= or $43,

so 1/= is $\frac{43}{300}$ or 14 cents.

Using these figures, charcoal at 20/= cost $2.40 to $2.80 in U.S. dollars.

14. How is charcoal made in the U.S.?

15. What are the uses of charcoal in the U.S.?

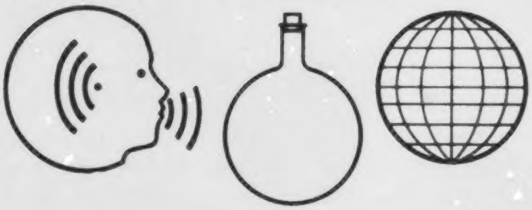
16. Why is fresh milk heat-treated?

(Like "pasteurization," the term more common in U.S., ultra heat treatment destroys several kinds of disease-causing organisms without much change in the chemical composition of the milk. It also slows the natural fermentation of milk, so it tastes fresh longer.)

17. What are the energy-related advantages of dried milk?

(Extra heat is required to process dried milk. However, this "expense' is more than offset by great energy savings in refrigeration, packaging materials, and transportation costs in distributing milk. Removing the water reduces the weight of milk by 90% and the volume by 75%. No refrigeration is required until or unless the milk is remixed with water for drinking. If kept dry, the milk powder lasts for months.)

18. If wood and charcoal were the only fuels available, how might food preparation methods and daily menus be affected?



Man, Energy and Environment

Some Attitudes and Beliefs

Background:

Planet Earth is often thought to be a mine to be explored, dug into, and reshaped for the benefit of humankind. It is a huge, non-living warehouse stocked with goodies for people who have the initiative to look for its resources and secure them for their immediate needs and comforts. Some examples of the attitudes and beliefs that typically accompany reliance on underground treasure are:

We'll never run out of energy stocks. (There are no limits.)

Scientists will find substitutes or invent better machines. (Technology can "fix" most problems.)

Bigger is better. (Overconsumption is health, virtue, or reward.)

The more I have, the better off I'll be. (Status and material security are very important.)

Growth is natural; let it go as it will. (Competition, individual strength, "survival of the fittest" determine success.)

Our country is so rich and so complex that waste is inevitable. We can afford it. (Waste is a status symbol. Effluents = affluence.)

Conservation isn't my job . . . . I didn't cause the shortages. (Personal contributions to a collective problem and its solutions are not recognized.)

There's no time like the present. I'll take my share now.

This sampling of some common responses to the "energy crises" is not one consistent viewpoint. The American, seen as an heir to limitless supplies, is considered blessed; entitled to use up resources at whatever rate chosen and not personally responsible for unpleasant side-effects. On the other hand, the individual depends on specialists to solve problems, on machines to do work, and on material things as bases for comfort and esteem. Ownership and control involve little direct responsibility.

A person having several of the beliefs listed above is probably very dependent on the current growth spiral and does not think much about the future effects of today's decisions. But rapid exploitation of Earth's resources, especially those that cannot be replaced over the span of a human lifetime, is an extravagance that may limit Earth's hospitality toward future generations.

Another viewpoint that has been persistent in many human cultures, including that of Native Americans, is that Earth is our mother. She is seen as a productive and nurturing being on whom all other living creatures depend. As such, she is to be revered and disturbed as little as possible. Quarrying, mining, and even plowing are seen as hurtful scars that mark where humankind has torn the womb of its mother.

Similarly, the metaphors of Earth as a garden to be carefully tended or as a spaceship wherein closed systems demand careful and timely recycling both recognize the interdependence of humankind and its natural home. Control then means finding out the best means of operating, preventing problems by appropriate maintenance, and promoting cooperation among all the living so that the planet's capacity for storing energy in living things is not carelessly reduced. Efficient management of the spaceship or long-term fruitful tending of the garden are virtues.

There are many other ways to look at man-and-energy relationships. The mine-pit, mother, garden, and spaceship images are just some examples of well-developed analogies that can provide standards for comparison to the articles by Lewis Thomas and Earl Cook that follow.

Recommended Resources:

1. "You ask me to plow the ground. Shall I take a knife and tear my mother's breast? Then when I die she will not take me to her bosom to rest.

   "You ask me to dig for stone. Shall I dig under her skin for bones? Then when I die I cannot enter her body to be born again.

   "You ask me to cut grass and make hay and sell it and be rich like white men. But how dare I cut off my mother's hair?"

Smohalla of the Nez Perce
(about 1850)

This is one of the many powerful expressions of the Native Americans' beliefs incorporated in Touch the Earth, T. C. McLuhan, ed., New York: Promontory Press, 1971. $7.95 (hardback).

2. "One of the interesting things to me about our spaceship is that it is a mechanical vehicle, just as is an automobile. If you own an automobile, you realize the you must put oil and gas into it, and you must put water in the radiator and take care of the car as a whole. You begin to develop quite a little thermodynamic sense. You know that you're either going to have to keep the machine in good order or it's going to be in trouble and fail to function. We have not been seeing our Spaceship Earth as an integrally-designed machine which to be persistently successful must be comprehended and serviced in total."

This viewpoint is the subject of a small paperback by R. Buckminster Fuller, Operating Manual for Spaceship Earth, Southern Illinois Univ. Press, 1969, $1.95. Chapter Four is a short essay within grasp of most high school students.

Activity Suggestions:

1. Copy one or both of the following articles for student use. Read the essay(s) in class, list the key ideas on the chalkboard, and encourage discussion of the attitudes and beliefs each author expresses.

2. Assign each student to present one of those beliefs in some tangible form--a brief essay of his own; a drawing; a listing of local ordinances that reflect man-energy-materials priorities; a TV commercial; a collage; a collection of newspaper articles or editorials; or a photographic assembly of human activities that display a particular viewpoint.

3. Have students collect ads that express values about the use of energy materials. Ask each student to bring in two or three ads and to write a sentence or two about
   a. the attitude or beliefs of the advertiser as stated or implied in the ad;
   b. the effect of the picture and/or text on the student reader.

4. Use a statement from the first paragraph of the Background information as the hub of a futures wheel (See TRENDS AND CONSEQUENCES activity). Assume that this belief is the basis for everyday choices and actions by the majority of Americans. What trends and consequences can students predict?

(Note: Discarded copies of Forbes, Fortune, New Yorker, Business Week, and the Wall Street Journal, are especially good resources for this activity.)

ENERGY FOR MILLENIUM THREE

by Earl Cook

Although it is a brief time in the evolutionary history of our planet or of the life on it, a millenium is a very long time to most people. Only a few, whose professional interests are defined in terms of time--historians, for example--can deal with 1,000 years with any sense of being relevant to the present human scene. I suspect it is a minority who consciously plan even in terms of their own adult lifetimes--say 50 years.

The public decision-maker is even more restricted in his conceptual time scale. Only a dictator can presume to visualize a "Reich of a thousand years"; the decision-maker in most modern governments has difficulty considering any problem that has not already thrust itself forcibly into the minds of his constituents, who then demand immediate solutions.

It may then seem only a pleasant intellectual excursion without practical significance to attempt to look either back or ahead on a scale of centuries at man's use of energy resources. Given the exigencies of public decision-making, this venture may be just an intellectual excursion and nothing more. But bear with me before making your judgment.

Variables in the Man-Energy System

The variables that must be dealt with in analyses of the relations of man and energy include time, the physical limits of both energy production and consumption, supply, demand, technology, cost, population, culture, and government.

Except for time and physical limits, these are not independent variables, as some of them are often treated. Demand is directly proportional to population, to cultural level, and to consumption technology; it is indirectly proportional to cost, at least as perceived by those who make resource decisions. Supply is directly related to the physical limits of the resource and of sinks for disposal of wastes; supply can be increased by technology and restricted by cost. Technology is limited by cost but expanded by the degree of inventiveness, ingenuity, and affluence inherent in a particular culture as well as by the ability of government to encourage and use it.

The relations between population, culture, government, and energy are particularly important. Population and culture are dependent on the rate of energy supply, where "culture" is taken to be the average standard of living. Government, defined as the ability to make and implement decisions designed to preserve the society and its members, is also a function of the rate of energy supply.

206

Historical evidence of these assumed relations of population and culture to energy supply might indicate that they have some validity.

Population and Energy Supply

Throughout most of man's history, his population has increased as his control and consumption of energy has increased. In other words, population growth has taken place in surges that reflect leaps in man's increasing control of energy.

An illustration is afforded by the history of China during the past 1,000 years (Figure 1). During this millenium each sharp rise in Chinese population can be nicely correlated either with extensive cultivation of a new or improved food plant or with intensive use of fertilizer and increased use of fossil fuels; each peak in population can be correlated with saturation of the land area adaptable to the new crop, and each subsequent decline in population can be correlated with declining agricultural production brought about by overplanting, soil depletion, erosion, flooding, and subsequent civil war or invasion.

Government and Energy Supply

That the stability of governments is a function of energy supply is also shown by the Chinese history, wherein each major decline in energy supply has been accompanied by a change of dynasty or form of government.

This correlation is perhaps more than merely coincidental. The ability of government to make and implement decisions calculated to preserve a society is a function of the energy supply to that society.

In a primitive agricultural society where the energy supply is barely sufficient for the subsistence of its members, government in the decision-ability sense is replaced by attitudes, mores, and conventions which have the force of law and which direct behavior along set lines; it is very difficult for an individual or a group of individuals to effect change in such a society, even if that change appears to them necessary for its survival. In addition, there is no surplus energy in such a society to support planners, thinkers, and administrators. The energy-deficient society tends toward overspecialization in the evolutionary sense and is not adaptable to changing environmental conditions (such as drought) or competition with a higher-energy society. An increase of energy supply in such a hardened society is most apt to result in an increase in population rather than the creation of the surplus required to raise its cultural level and enlarge its perceptual scale for decision . . .

Reprinted with permission of the author and publisher from Technology Review, Vol. 75, No. 2, pp. 16-19. Copyright 1977 Alumni Association of the Massachusetts Institute of Technology.

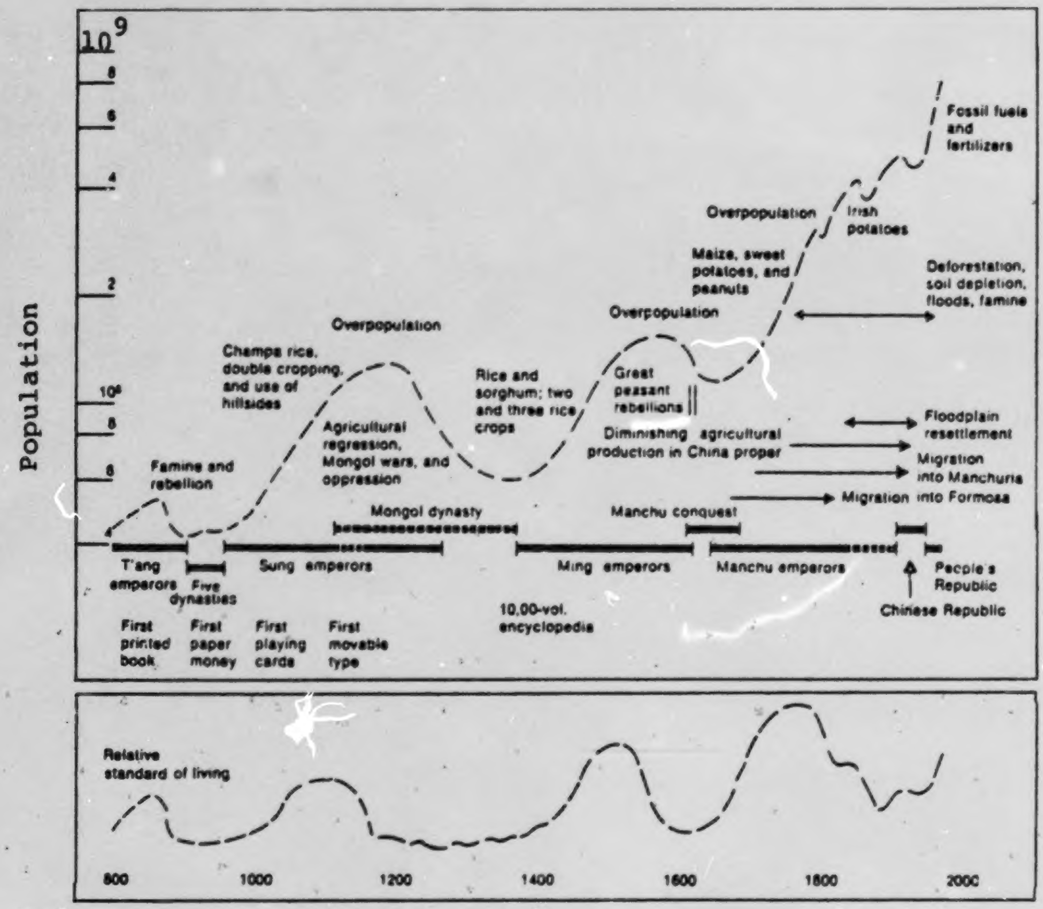


Figure 1. China's history demonstrates the interrelationship of energy and culture (expressed here as standard of living). The introduction of new food plants allowed cultivation of previously unusable land; new varieties of rice allowed double-cropping and planting on land above flood plains; maize and sweet potatoes could be planted on mountain sides, and the Irish potato on mountain tops. In each case, energy supply increased. But erosion, soil depletion, flooding and famine were inevitable, as was, apparently, a change in government, when the energy supply receded.

Note that the vertical scale is logarithmic. Population of China swelled as croplands were expanded, new foods were introduced, and food supply increased. (Basic data from Ping-Ti Ho, 1959.)

PAGES 377-380 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

The Baker's Dozen

1. List all electrical devices in your house.
2. Total this list.
3. Check around the class to see who has the longest list. Read it aloud so others have a chance to add any appliances they may have forgotten.
4. Check the 13 electrical devices that are most important to you.
5. Draw a line through the four you can most easily do without.
6. Draw a circle around the four you could least easily do without.

Limit yourself to a one or two paragraph answer for the following questions.

7. What causes black outs and brown outs?
8. Who actually controls a public power company?
9. What are the particular advantages of electricity?
10. What do you do to conserve electric power?
11. Generate a list of essential services which require electricity that you and your community are dependent upon.
12. Explain how power companies contribute to air and thermal pollution.
13. Describe how your favorite electrical device may be powered in the year 2010.

Student activity suggested by Paul D. Knapp, Linn-Mar High School, Marion, IA.

Cabin Fever I

Surface Area

Introduction:

Heat naturally travels from a warmer place to a cooler one, or from an energy "source" to an energy "sink." How quickly that transfer happens depends on many factors. In the case of buildings that need heating or cooling, some of the considerations are:

How much surface area is conducting heat? (CABIN FEVER I)
How well insulated is it? (CABIN FEVER II)
How tightly sealed is it? (CABIN FEVER III)
What does the site and its plantings contribute to the energy flows? (CABIN FEVER IV)
What are the activities of its occupants? (CABIN FEVER V)

Surface area or "skin" of a building varies with its design. The more exposed "skin," the greater is the potential for heat transfers. However, the smallest house is not necessarily the most efficient. For many designs, small increases in linear dimensions yield larger increases in volume. Even for homes or apartments of the same floor area or living space, their general shape and arrangement makes some more efficient than others. In general, the larger the volume of inside air to the outer surface areas of floor, walls, and roof, the slower the rate of total heat exchange between the inside and the outside.

Background:

In order to consider the amount of surface area conducting heat. we need to calculate floor area, volume, surface area, and the ratio of volume to surface area. Let's consider each of these factors in turn.

a. Floor area is length times width on the rectangular plans, with 8 ft. being the height of each unit. The "L" plan is best calculated in sections. The "A" frame has a standard rectangular base, 30 ft. x 35 ft. The dome has a circular floor for which the area is πr^2 or 3.14 x 18 ft. x 18 ft.

b. Volume involves all three dimensions, length x width x height. Again, the "L" is best considered as the sum of each rectangular section. The A-frame is 1/2 of the cracker box (rectangular solid), or area of the triangle times length. The dome is 1/2 of a sphere so its volume would be $1/2\ (4/3\pi r^3)$.

c. Surface area includes all wall, floor, and ceiling areas.

For the "ranch," for example, you have both a floor and a ceiling 24 ft. x 43 ft.; there are two walls 24 ft. x 8 ft. and two walls 43 ft x 8 ft. So total surface area is:

2 x 24 x 43 = __________
+ 2 x 24 x 8 = __________
+ 2 x 43 x 8 = __________

Total: __________ sq. ft.

Some formulae to recall: Area of a triangle is 1/2 altitude times the base. Area of a circle is πr^2. Surface area of a hemisphere is 1/2 πd^2.

d. A ratio is a comparison between two figures. In comparing the volume of air enclosed to the outer surface area where exchanges of heat take place, we are assuming that air escapes the way people leave a supermarket, taking the shortest "line" out. If the number of check-out counters varies from market to market, the same volume of customers will be served faster in some stores than others. Similarly, if the surface area figure is close to that for volume, the ratio will be a small number (fast exchange, "short line" at the check-out). If the surface area is limited compared to the volume, the ratio will be a larger number (slower exchange, "longer line" at the check-out).

Because interior air has been deliberately heated or cooled at some energy cost, slowing down its exchange is desirable. Designs that provide a minimum exterior surface in relation to interior air space (higher ratio) are likely to require less energy for space heating and air conditioning than designs having a low ratio. This assumes that the buildings being compared are alike in materials, construction, insulation, window area, occupants and other energy-use related factors.

Directions:

With this in mind, compare the heat retaining advantages of various shapes for some modest homes. Using the dimensions given on the following chart, do the calculations necessary to complete it.

After you have completed the chart, answer the following questions.

1. How similar are these houses/apartments in functional living area?

   a. What is the average floor area of each living unit. Assume for the sake of your calculations that the 2-Story Square is a duplex (first calculate its average floor area). Make the same type of calculation for the 4-Unit Apartments.

b. Which house plan shows the largest difference (plus or minus) from the average floor area?

c. Using your calculations in 1b, determine the largest percent of difference from the average floor area.

$$\frac{\text{Largest Difference in Floor Area}}{\text{Average Floor Area}} \times 100 =$$

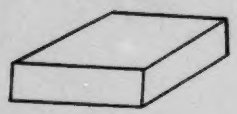
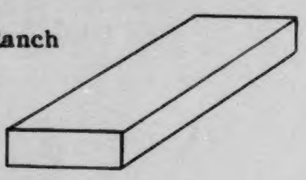
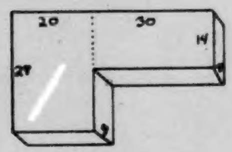
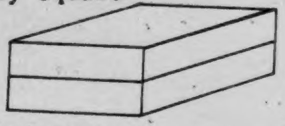
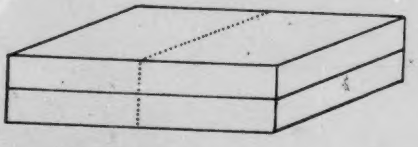
2. Which design has the best potential for slowing down heat losses?

3. Which design would be easiest to insulate? Describe how you would do it.

4. Can you suggest another design that would be better in slowing heat transfers?

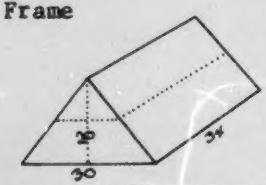
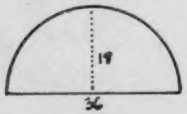
Name ______________________________

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
Square 	32 x 32 x 8				
Ranch 	24 x 43 x 8				
Small "L" 	20 x 28 x 8 and 30 x 14 x 8				
2-Story Square 	32 x 32 x 16				
4-Unit Apartments 	64 x 32 x 16				

Name

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
"A" Frame  	30 x 34 x 20 ft. peak				
Dome  	36 ft. = diameter, 18 ft. = radius				

1. a.

b.

c.

2.

3.

4.

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
Square	32 x 32 x 8	1,024	8,192	3,072	2.67
Ranch	24 x 43 x 8	1,032	8,256	3,136	2.63
Small "L"	20 x 28 x 8 and 30 x 14 x 8	980	7,840	3,208	2.44
2-Story Square	32 x 32 x 16	2,048	16,384	4,096	4.0
4-Unit Apartments	64 x 32 x 16	4,096	32,768	7,168*	4.57

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
"A" Frame	30 x 34 x 20 ft. peak	1,020 + loft	10,200	3,320	3.07
Dome	36 ft. = diameter 18 ft. = radius	1,017.4 + loft possible	12,208.3	2,034.7	6.00

---

1. a. Average floor area/living unit + 1,017.3 ft.^{2}

   b. Small "L" house shape

   c. 3.6%

2. In terms of potential, the dome is best due to less escape routes for heat transfer.

3. There is no one right answer. Ease of insulation depends upon local limitations on construction, materials, installation expertise, costs, and time.

4. A number of valid suggestions may be proposed including berming, double wall or envelope construction, underground homes, row housing with shared walls, windowless north walls, etc.

Cabin Fever II

Insulation

The second factor affecting how fast heat transfers in or out of a building is the materials of which that building is constructed in the first place. The exterior surface or "weatherskin" transfers heat into or out of the house at a rate that varies with the kinds and thickness of materials incorporated into the walls.

Every building material has its individual insulation value. It can be expressed as U, coefficient of heat transfer (BTU/hr/ft^2/°F), or the resistance to heat flow (R). These values are reciprocal: $U = \frac{1}{R}$. The higher the "R-value," the better the resistance to heat loss. R-values are additive--thicker material or a combination of materials usually means increased insulating value.

Typical Heat Resistance (R-Value) of
One Inch of Various Materials

Material	R/inch
polyurethane foam	6.25
shredded newspaper	5.50
polystyrene board	5.26
cellulose (loose)	3.70
fiberglass (batt)	3.17
perlite	2.70
rock wool	2.20
softwood (fir, pine)	1.25
air space	0.91
dry snow	0.80
light, dry soil	0.40
plaster	0.18
heavy soil, damp	0.09
concrete	0.08
average rock	0.06

Source: ASHRAE Handbook of Fundamentals and J. Scalise, Earth-Integrated Architecture.

Amount of air spaces or pockets separating the solid parts in the material is a second important determinant of its ability to slow heat conduction. The more air spaces and the lower the conductivity of the solid between them, the better the insulation value. So it should not be surprising to find that popcorn and shredded newspapers are good insulators. (A large air space is not a good insulator because convection currents develop which assist heat flow.)

Reflective metal coatings can also act as effective barriers against heat loss. Aluminum, chrome, silver, or other shiny surfaces reflect long-wave (heat) radiation. Adhesive metallic films for windows are comming into use, making "heat mirrors" of these openings without blocking an insider's view. If this foil has an air space in front of it, it can reflect up to 95% of the heat energy before the heat is absorbed by the insulation or glass and conducted outward. Architect David Wright reports that a 1/4 inch airspace, when lined with foil, attains an R-value of 2.5.

R-value alone is not the criteria for selecting building materials or added insulation. Fire-resistance, structural qualities, pest control, space availability, cost-effectiveness, ease of installation, and energy required for production and delivery are some of the other factors to be considered in determining the best choice for a particular building and location.

Since heat rises, the ceiling is the most important part of buildings to insulate well. It keeps more heat in the room and slows its escape upward. This stabilization then reduces the air exchange rate and the pulling in of colder outdoor air. The furnace will run less, the interior will be more comfortable, and energy savings can be expected.

Well-insulated walls and floors are also very important, however. In order to get "thermal balance" or even heat throughout a home, new dwellings designed for energy efficiency use more insulation in exterior walls. 2" x 6" studs permit thicker walls and more insullation in conventional construction. "Arkansas Plan" houses built with 6" wall and 12" ceiling insulation (R-19 and R-38) have been using one-third the heating and cooling dollars of standard new homes.

Suggestions for Student Activities:

1. The Iowa Extension Service in Ames and many local utility companies provide an "energy audit" service. Call or write for audit forms on which students list basic features of their homes, apartments, or school: number of windows, length of exterior walls, floor areas, style and number of exterior doors, etc. Counting and measuring can be done by junior high students; only basic math skills are required. Send the forms back to the sponsor for a computer-assisted analysis of likely places that changes in the building or in the activities of its occupants may save energy, or consider doing the economic analysis with the help of a detailed, step-by-step instructional booklet, "In the Bank or Up the Chimney." Published by HUD, this resource is available for $1.70 from the Sup't. of Documents, Government Printing Office, Washington, DC 20402. Ask for # 023-000-00297-3.

2. Use several identical packing boxes as "model houses." Put a thermometer inside each in such a way that it can easily be read without disturbing the box. Make a small window, of the same size and material for each box. Put a second thermometer on the outside of each box. Line the walls and "ceiling" of each box with a different kind of insulation. Put each box over a liter beaker full of boiling water or full of ice cubes and record temperature differences (inside vs. outside and box 1 vs. box 2, etc.) over time.

   You may want to use the "thermos bottle" analogy in introducing this activity. A good thermos has a high surface-to-volume ratio, excellent insulation, a radiant barrier, and only one or two well-sealed openings. It works equally well to keep cool things cool and warm things warm. Slowing heat flow works both ways in a well-designed and insulated building.

3. Build an igloo on the school grounds in winter. Tamp snow firmly into shoe boxes or similar containers. If it is not "packing snow," add some water and let the blocks freeze solid. Pile up "blocks" on a circular base, leaving an opening on the south side. Make each successive layer overhang the previous one slightly on the inside. Use extra snow "mortar" if desired to smooth interior walls. When completed, temperature measurements of inside (warmed by student workers) can be compared to those outside. Ask students to explain differences and to suggest improvements that would make the structure a better heat-conserver. Research on housing styles (past and present) within the Arctic Circle would be appropriate.

4. Contact a local banker, savings-and-loan officer, or home builder familiar with F.H.A. requirements. Ask what current construction practices have been recently adopted with energy conservation in mind. Collect pictures and floor plans of contemporary homes or other buildings where people work, shop, or recreate. Label features that meet or exceed basic requirements for energy efficiency.

5. With cooperation of the school custodian, maintenance supervisor, or other knowledgeable person, survey the school facilities with energy efficiency in mind. Is the school insulated? how? Could insulation, storm windows, shutters, drapes, lowered ceilings, or other energy-saving features be added? Or could activities of the people in the building be changed to save energy? Keep in mind that each person in the school gives off about as much heat as a 100 watt incandescent bulb burning continuously. Can that "people-power" be used?

6. Cars, trailers, and motor homes are also "weatherskins" that shelter people from the climate. Cars, at least, are likely to be available on the schoolgrounds and could be subjects for heat-flow measurements. In the Sun, in the shade; windows open, windows closed; different colors, varying amounts of glass area, trunk vs. hood vs. passenger compartment temperature changes over time are all possible forms of data to collect on the efficiency of vehicles to resist heat flow.

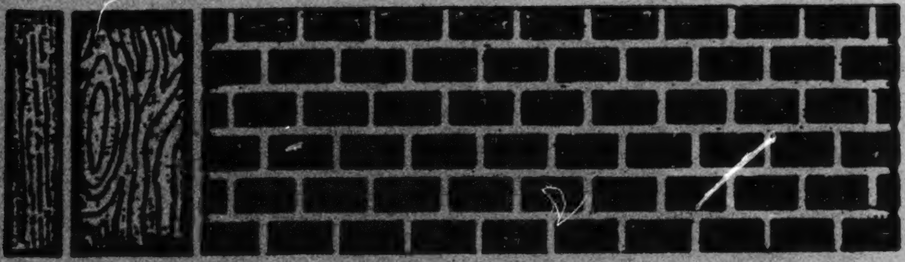
224

Be prepared to discuss conflicting requirements for cars. They should be strong enough to resist demolition; light enough to be economical in use of fuel; comfortable enough to make traveling pleasant; good-looking enough to make people want to buy them. Are there materials that can satisfy those criteria and also minimize heating and cooling requirements for passengers? What would they cost? Would changing people's habits, needs, or expectations be easier than making energy-efficient cars?

Have some students check the additional cost of factory-installed air conditioning on several models of cars, as well as weights of the units. Remind them that these additional 300-500 pounds will reduce fuel economy every time the car is driven--winter or summer--because the greater the weight moved, the greater the amount of fuel needed to move it. Further, when an auto air conditioner is in operation, its use reduces fuel economy by 1-2 mpg, most automotive guides report. How many days a year is this option necessary? How much does it cost to have it available for those days? What other alternatives do motorists have?

Free Resource Suggestion:

Home Energy Savers' Manual, James W. Morrison, ed., 1979, available from Iowa Energy Policy Council, 707 E. Locust, Des Moines, IA 50319. Single copies are available free to teachers. Classroom copies may be available at cost; write for a quotation.



Forget inches: It's R-values that count.
6 inches of fiberglas have the same R-value as 15 inches of wood or 7 feet of brick

The insulating value of any material depends on both the R-value and the amount (thickness) used. The two variables must be juggled simultaneously.

Some insulation guidelines mention inches only, as if quantity and quality are the same. Others specify R-value per inch only. But these are both important and inter-related variables. Total R-value is the sum of R-rating/inch times thickness of the material(s) used over a particular area.

In unfinished floor attics with only 2"-3" space available for insulation, the highest R-value may determine choice, giving maximum resistance possible in a fixed area. But where space is not a limiting factor, cost or availability or ease of installation may make a lower R-inch material, used in quantity, the best choice. Where underground buildings are possible, low R-value masonry and earth berms several feet thick may be the most practical choice for an energy efficient building.

Cabin Fever III

Infiltration

In many homes the greatest single factor in heating and cooling losses is infiltration. Infiltration is the outside air coming in through open doors and windows; through cracks around windows, doors, skylights, and vents; and through any other break in the "weatherskin" of a building, such as fireplaces, water faucets, exhaust fans, electrical outlets, and joints where different materials meet.

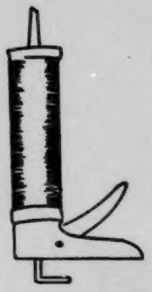
In a poorly sealed house, inside air may leak out and be entirely replaced every fifteen minutes.

Temperature differences alone start these air-exchanges. Warm air naturally flows to cooler regions. But wind can make the rate of infiltration much higher. Wind creates a pressure differential that forces air into a building on the windward side while it sucks air out of the leeward side.

Wind speed also makes the effective or humanly experienced temperature less than the actual thermometer reading. Wind chill factor is the relationship between cooling conditions at various temperatures and wind speeds, as measured by the freezing rate of water sealed in a plastic container. Such a set-up is equivalent to human flesh. It was devised by Antarctic experimenters to learn how fast their faces would freeze under its severe weather conditions. The super-cooling effect of wind has relevance to heating requirements also, especially in poorly-sealed buildings or in those sited where high winds are prevalent. Occupants will likely feel chilled on windy days even if the furnace keeps the room air at an ordinarily comfortable temperature.

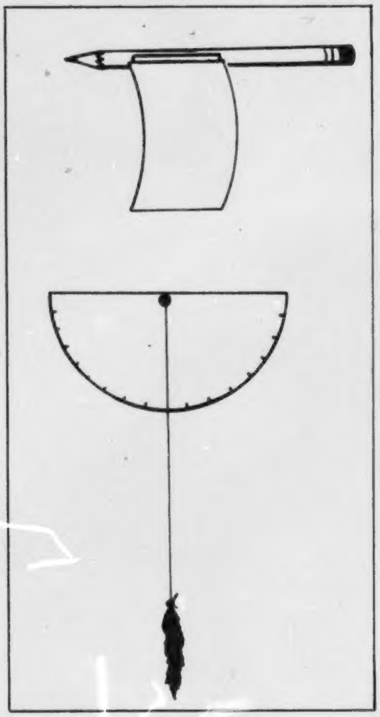
The main methods of stopping infiltration are caulking and weatherstripping.

Caulking is soft material that can be squeezed into all non-moving cracks and joints of a building. Areas that commonly leak air and should be sealed are the space between walls and floors; where the outside wall meets the foundation; around window and door frames, electric outlets, ducts and vents, and any pipes that penetrate foundation walls; around the chimney shaft as it passes through the attic; and around recessed light fixtures.



Weatherstripping is used around windows and doors that open and close. Many kinds are available to reduce air flow around their edges. A door on the windy side of the house will likely need more than weatherstripping or a storm door to prevent infiltration, however. An enclosed vestibule is recommended if this entrance must be used.

Suggestions for student activities:



1. Construct a draft detector from a pencil, scotch tape, and plastic food wrap. Cut a 12 x 25 cm strip of plastic wrap and tape one of the 12 cm sides to the pencil. Blow the plastic gently to see how freely it responds to air movement.

   OR

   Construct a draftometer from a protractor, push-pin or thumb-tack, thread, and a feather. Tie one end of 60 cm of thread to the tack or pin. Attach the feather to the other end. Push the pin through the hole in the protractor and hang it on the corkboard or window framing so that the bottom edge of the protractor is upward and level with the floor. Blow on the feather and notice how the thread intersects various places on the circular arc. You can use this device to make comparative measurements.

   Using either the draft detector or the draftometer on a day when forced-air furnaces are not operating, students can test the classroom and other school areas (or their homes and cars) for air leakage by holding or pinning the device near edges of windows and doors, by fireplace openings and by ducts or vents. Encourage record-keeping on length (perimeter) and the location (N, S, E, W) of openings that showed evidence of drafts.

2. Visit a hardware store to find out what is available to close air leaks around various openings. Or invite a local merchant to display and explain the use of caulking and weatherstripping materials to the class. Or bring in examples of weatherstripping and let students practice installing some under supervision on the school building or on a nearby home.

3. Using examples of at least three different types and prices of caulking cartridges and a caulking gun, have students press out beads of caulking onto broiler foil or onto small pieces of wood. Label the various examples for later identification. Arrange to heat-dry the samples (in your solar oven, if available--or at 150°F in a conventional oven); and then freeze, heat-dry and freeze the samples again for several consecutive days. Have students note any observable differences (in color, hardness, shrinkage, cracking, etc.) between the various samples. Encourage cost-effective comparisons. The following chart is suggested for record keeping:

CAULKING: Life-Cycle Costing

Type	Price	Useful Life	Cost per Year
Oil or resin	(low)	1-4 years	
Acrylic, latex, butyl	(moderate)	3-12 years	
Elastomerics: hypolon, polysulfide, silicon	(high)	10-20 years	

Resource Suggestions:

"Consumer's Guide to Caulking" in Mechanix Illustrated, September 1976.

"Sealing the Leaks" in How to Cut Your Energy Costs, U.S. News and World Report Books, $7.95, 1978.

"Save Energy, Save Dollars," a consumers' manual about conservation of energy in the home, available for $1.50 from Mailing Room, 7 Research Park, Cornell University, Ithaca, NY 14853.

Wind Chill Factor

Thermometer (°F)	Wind speed (mph) 5	10	15	20	25	30	35	40*
35	33	21	16	12	7	5	3	1
30	27	16	11	3	0	-2	-4	-4
25	21	9	1	-4	-7	-11	-13	-15
20	16	2	-6	-9	-15	-18	-20	-22
15	12	-2	-11	-17	-22	-26	-27	-29
10	7	-9	-18	-24	-29	-33	-35	-36
5	1	-15	-25	-32	-37	-41	-43	-45
0	-6	-22	-33	-40	-45	-49	-52	-54
-5	-11	-27	-40	-46	-52	-56	-60	-62
-10	-15	-31	-45	-52	-56	-63	-67	-69
-15	-20	-38	-51	-60	-67	-70	-72	-76
-20	-26	-45	-60	-68	-75	-78	-83	-87
-25	-31	-52	-65	-76	-83	-87	-90	-94
-30	-35	-58	-70	-81	-89	-94	-98	-101
-35	-40	-64	-78	-88	-96	-101	-105	-107
-40	-45	-70	-85	-96	-104	-109	-113	-116

Wind chill index numbers represent the temperature (under calm conditions) that would have equivalent cooling power on exposed flesh or water.

*Wind speeds greater than 40 mph have little additional cooling effect.

Cabin Fever IV

Site and Plantings

If people consider Sun, wind, Earth, and trees as natural heaters or air conditioners, they can make use of their effects to improve comfortable living and reduce its cost. The setting of a home on its site and the landscaping around it can affect how sunshine and wind flow over and into the living quarters. Tests done in New Mexico show that surface orientation alone can affect a heating bill as much as 16%.

The terrain on which a house is built can be a factor in its heating requirements. Cold air sinks. Buildings located in valleys or on the north side of hills are often bathed in colder air than are counterparts on higher and sunnier slopes. Protection from winter winds by a hillside, earth berms, trees, neighboring buildings, or a tall fence can cut heat losses from levels that more exposed buildings experience. A large pond built where the wind blows over it before meeting the house can also moderate its effects.

Prevailing winds vary with the season. In Iowa they generally come from the northwest in winter, the southwest in summer. Your local weather bureau can tell you the recent history of wind patterns in your area.

If your house is not already well-protected from the winter winds, consider planting appropriate trees or shrubs to divert the mainstream of the wind from your house.

On the north, northeast, and/or northwest sides of the house, a windbreak of evergreen trees can reduce infiltration, wind chill, and snowdrifts. Ends of the windbreak should extend 50 feet beyond the end of the area to be protected. Ideally, the trees should be dense hemlocks, fir, or spruce and be planted at a distance four to five times the height of the house to be protected. A single row of evergreen trees as tall as the house can reduce air infiltration 40% according to researchers at Princeton University who tested scale models in a wind tunnel. City dwellers may have a neighboring house standing close enough to provide a man-made windbreak. Or a tall fence can provide a satisfactory windbreak wherever trees are not practical.

On the southeast, southwest, and south where trees may be needed both for summer shade and for windbreaks, deciduous trees (those that drop their leaves every fall) are the better choice. They won't block the winter Sun that can help warm the building. (Every home is a passive solar home, gaining some solar heat no matter what its design. But some homes trap that heat much more efficiently than others. Give your existing home every advantage.) Deciduous trees also shade the house during summer months, and release significant amounts of moisture to the night air; both activities have a cooling effect.

Small evergreens planted near a foundation wall so that air space is trapped between the shrubbery and the house provide some additional insulation in addition to wind protection. Plants that grow to form a dense, solid wall of greenery are best.

If your homesite is unsuitable for growing trees, some alternatives for shade are roof overhangs, porches, vented awnings, shades, draperies, and beadwall windows. Insulated shutters can be used for windbreaks too. Most existing homes would use less energy for space heating and cooling if a combination of strategies is used.

If your home or apartment site already has considerable landscaping, look at the plants with a new critical "energy eye". Are they placed to work as natural heat savers and air conditioners or are they there merely for show?

Resources:

"Energy Efficient Construction in New Homes," pamphlet available free from Cooperative Extension Service of Iowa State University, Ames, IA 50011.

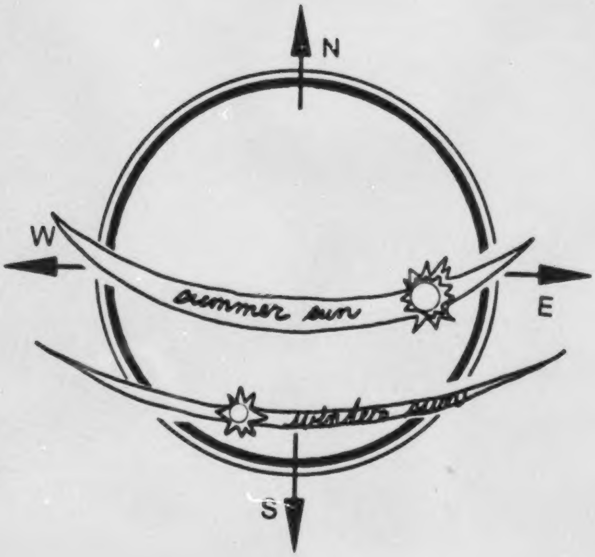
Natural Solar Architecture by David Wright (1978) includes much detailed information on site considerations presented in large-print and chatty style; illustrations on every page.

Solar Dwelling Design Concepts, U.S. Government Printing Office, Stock # 023-000-00334-1 (1976) features a dozen pages of diagrams and text on integration of siting, plantings and buildings.

Underground Design by Malcolm Wells (1977) is mostly drawings and photographs of imaginative building projects that maximize natural environments to conserve energy and to preserve visual appeal of the site. Despite the title, several of the earthy buildings described are above grade level, and some are even several stories high.

Activity Suggestions:

1. Ask students to do the following: Draw a large compass circle similar to this diagram and mark the N-S and E-W axes. Shade in the approximate path of the winter and summer Sun. Draw arrows outside the circle to indicate direction of prevailing summer and winter winds in your area. Then sketch the general shape of your house, school, or apartment building in the middle of the circle, being careful to keep its longest outside wall facing the same direction in your circle as it does on its lot.

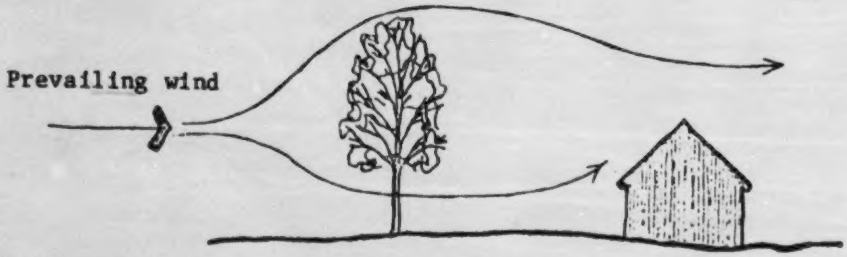


   Considering the paths of the Sun and wind relative to your building, where should shaders and/or deflectors be placed? Are there any plantings there now?

2. Invite a local nursery owner to your class to describe and show pictures of trees and shrubs that grow well in your area. Ask him questions about growing rate, longevity, soil requirements, wind resistance, and disease problems of common evergreens and deciduous trees. What is the basis of choice for most customers? How will energy shortages affect his business? What advice does he give for landscaping to conserve energy?

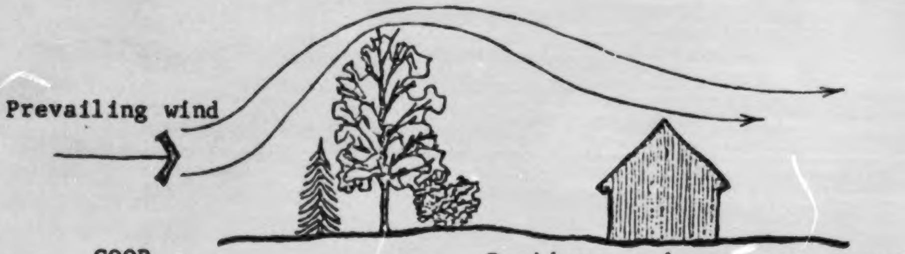
3. Assign students to ask a local builder or real estate developer about popular building sites in your area. Are hilly plots an advantage or a disadvantage and why? What site-related factors are most important to buyers today? Are these choices the same as those made 10 years ago? Is the energy situation likely to change people's site preferences in the near future? Are there any especially well-used sites (relative to energy conservation) in your area that your class may visit?

4. Encourage students to use the school or public library to look for articles in current magazines on earth-bermed, underground, solar-sited, earth-tempered, aerodynamic, and/or passive solar buildings. Readers' Guide to Periodical Literature is a good tool to use. Look for references under "homes," "landscaping," and "architecture." Make a model, poster, report on the most energy-conserving home you read about, or one that you can create by combining features mentioned in the readings.



POOR

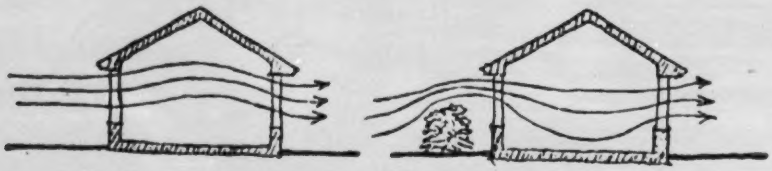
Deciduous trees



GOOD

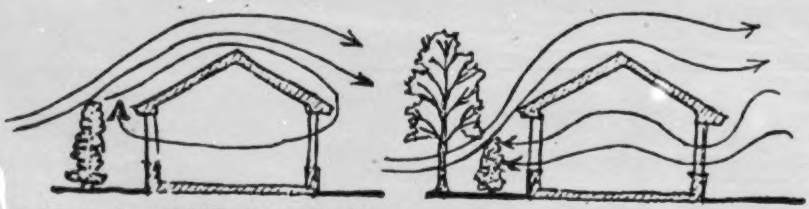
Deciduous and evergreen trees

Strategically located evergreens help deflect harsh winds



No plants

Shrubs next to building

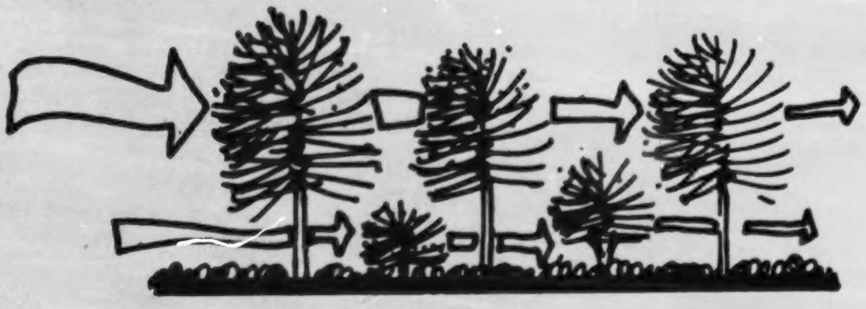


Tall hedge 5'0" from building

Tree 20' from building
Hedge 10' from building

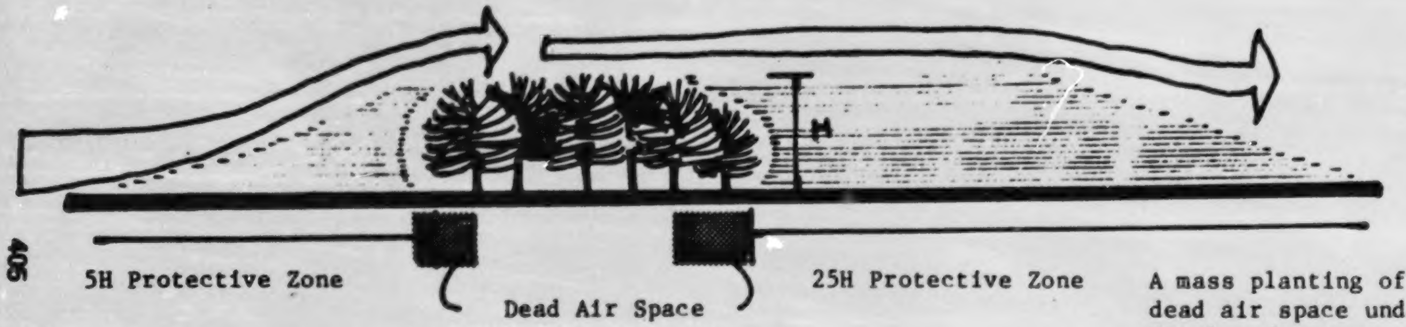
Strategically located plants can direct breezes into buildings in warm seasons and also act as windbreaks in cold seasons.

Reprinted from "State of Vermont Energy Conservation Guidelines," prepared by the Vermont Public Service Board and the Agency of Environmental Conservation (Montpelier, April 1974).

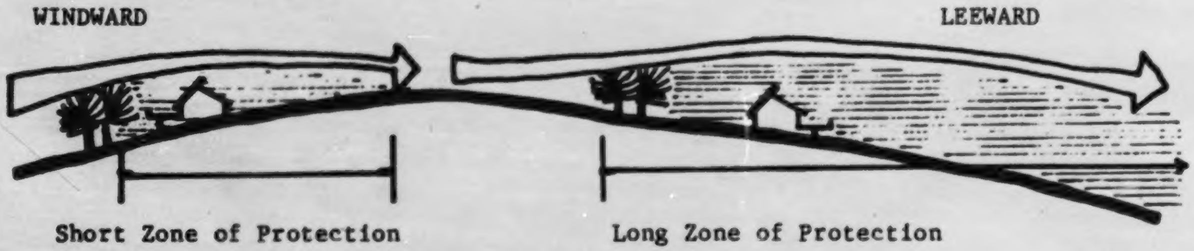


Multiple Braking Effect

Multi-layered vegetation including canopy trees and understory trees or shrubs provides a multiple braking effect, substantially decreasing the wind velocity moving over a site.


H
5H Protective Zone
Dead Air Space
25H Protective Zone

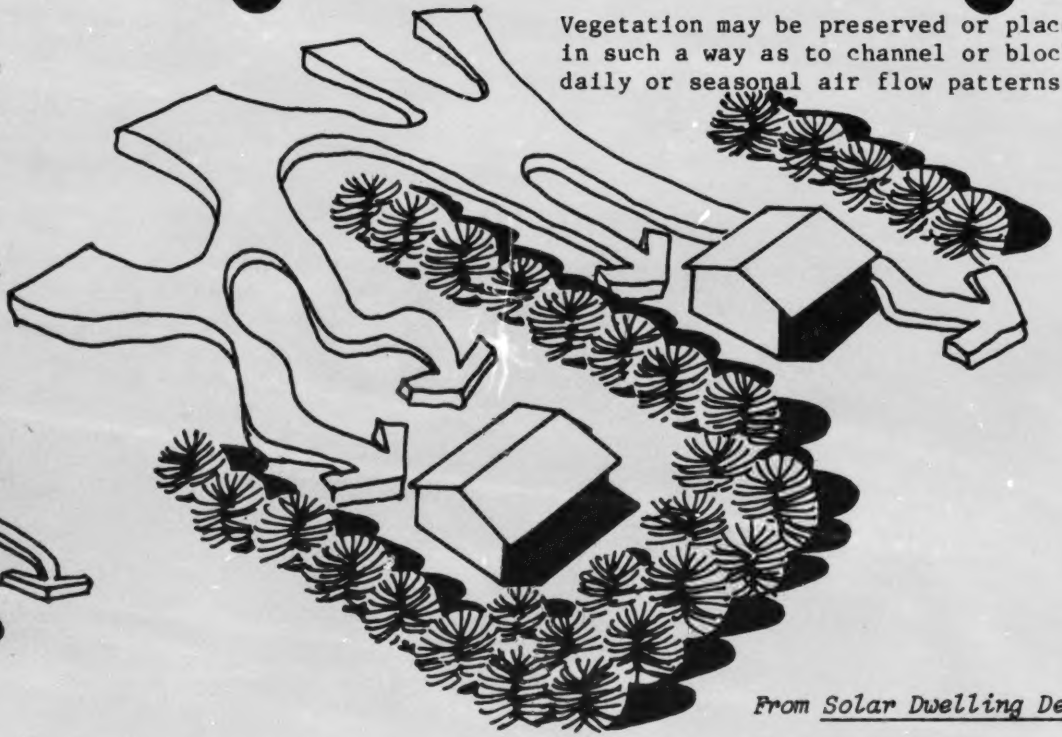
A mass planting of trees provides a dead air space under and around itself. It also decreases the air velocity 5 times its height to windward and 25 times its height to leeward of the planting.


WINDWARD
LEEWARD
Short Zone of Protection
Long Zone of Protection

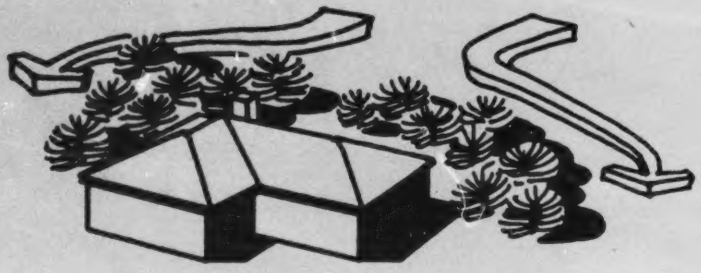
Planting on the leeward side of a hill substantially increases the downwind zone of reduced air velocity, while planting on the windward side correspondingly decreases the zone of protection.

From Solar Dwelling Design Concepts, HUD, 1976.

Fences, walls or vegetation can block natural air flow patterns. Care must be taken during site design to provide the necessary visual control while avoiding adverse climatic conditions, as cooler air flows downhill in the evening. Fences, walls or plantings should not unintentionally dam this flow and thus create a cold air pocket where it is not wanted.

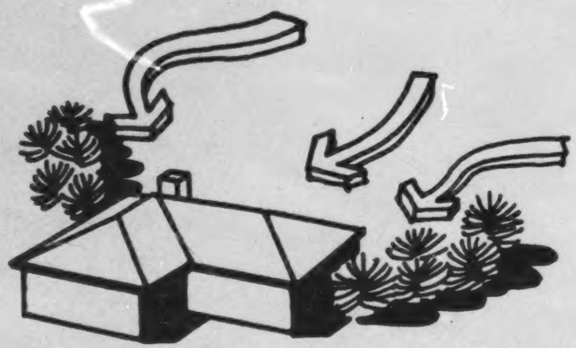


Vegetation may be preserved or placed in such a way as to channel or block daily or seasonal air flow patterns.

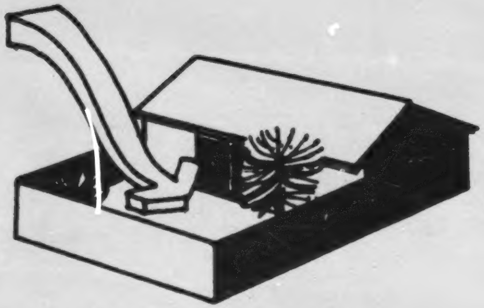


Vegetation properly placed can deflect rather than dam cold air flow.

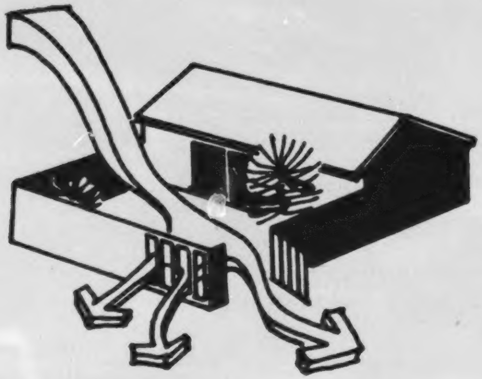
From Solar Dwelling Design Concepts, HUD, 1976.



Dwelling unprotected from cold air flow.



Cold air trapped by fence.



Fence design can provide for cold air drainage.

SITE ORIENTATION CHART

Objectives	Cool	Temperate	Hot Humid	Hot Arid
	Maximize warming effects of solar radiation. Reduce impact of winter wind. Avoid local climatic cold pockets.	Maximize warming effects of sun in winter. Maximize shade in summer. Reduce impact of winter wind but allow air circulation in summer.	Maximize shade. Maximize wind.	Maximize shade late morning and all afternoon. Maximize humidity. Maximize air movement in summer.
Adaptations				
Position on slope	Low for wind shelter	Middle-upper for solar radiation exposure	High for wind	Low for cool air flow
Orientation on slope	South to Southeast	South to Southeast	South	East-southeast for P.M. shade
Relation to water	Near large body of water	Close to water, but avoid coastal fog	Near any water	On lee side of water
Preferred winds	Sheltered from North and West	Avoid continental cold winds	Sheltered from north	Exposed to prevailing winds
Clustering	Around sun pockets	Around a common, sunny terrace	Open to wind	Along E-W axis, for shade & wind
Building Orientation*	Southeast	South to Southeast	South, toward prevailing wind	South
Tree forms	Deciduous trees near bldg. Evergreens for windbreaks	Deciduous trees nearby on west. No evergreens near on south	High canopy trees. Use deciduous trees near building	Trees overhanging roof if possible
Road orientation	Crosswise to winter wind	Crosswise to winter wind	Broad channel, E-W axis	Narrow. E-W axis
Materials coloration	Medium to dark	Medium	Light, especially for roof	Light on exposed surfaces, dark to avoid reflection

---

*Must be evaluated in terms of impact on solar collector, size, efficiency and tilt

From Solar Dwelling Design Concepts, HUD, 1976.

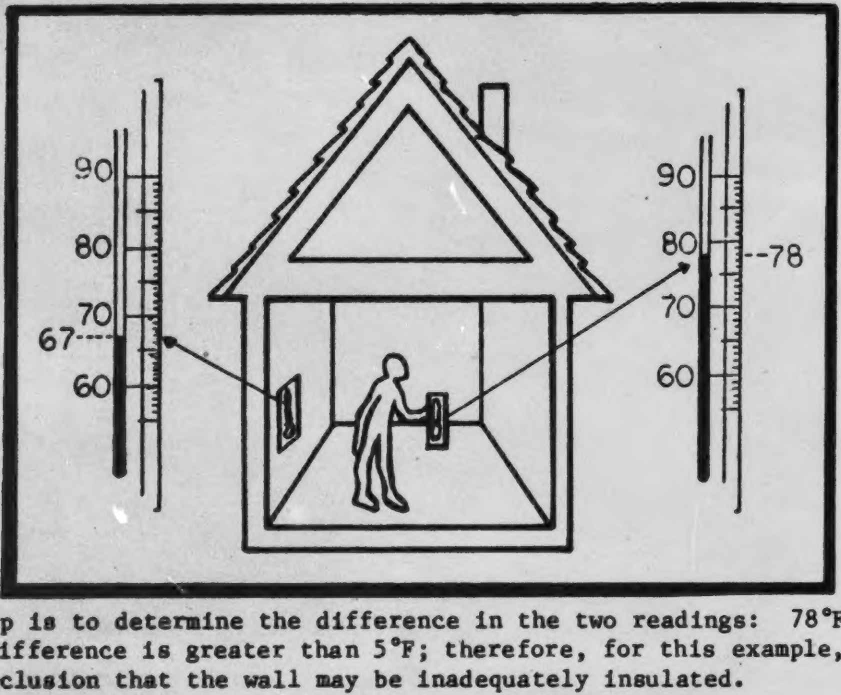
Checking Wall Insulation

Objective:

To determine the adequacy of wall insulation in a completed structure.

Directions:

During the heating or cooling season, when the heating or cooling equipment is operating, place a thermometer firmly against the inside surface of an exterior wall and another in the center of the room. It's easiest to hang the thermometer on a picture nail or hook on the wall, and place it in a chair in the middle of the room. Allow sufficient time for the temperatures to register and then record the two readings. If the difference between the two readings is greater than 5°F, the wall is probably not adequately insulated. The example illustrated below shows an exterior wall temperature of 67°F and a center of the room temperature of 78°F.



The next step is to determine the difference in the two readings: 78°F-67°F = 11°F. The difference is greater than 5°F; therefore, for this example, we would draw the conclusion that the wall may be inadequately insulated.

Now try this exercise at your house. You may wish to try it in several rooms with exterior walls.

Room ______________________________

Outside wall thermometer reading ___________
Center of the room thermometer reading _____________

The difference between the readings:

________________ - _______________ = ____________
(higher reading) (lower reading) (difference)

Is the difference greater than 5°F?

Another place that poorly insulated buildings show uneven temperatures is at floors and ceilings. Warm air rises, so small differences between floors and ceilings (1-2°F) can be expected. But if floors are uncomfortably cooler, people are likely to turn up the thermostat and overheat the rest of the building. Insulation can help prevent such imbalances.

Put a thermometer on the floor and hang another near the ceiling in the room you want to test. Allow at least five minutes for the thermometers to register. Then read and record their temperatures.

Room _______________________
Floor reading ______________ Ceiling reading _____________
The difference between the readings is ___________________
Is the difference greater than 5°F? _______________
What can you say about adequate insulation in this structure?

Are there reasons other than inadequate wall insulation which might cause a difference in the temperature readings? ___________ What might they be?

Suggestion:

Try this exercise in the classroom, gymnasium, and restroom in your school.

Activity adapted from Energy Conservation in the Home, An Energy Education/Conservation Curriculum Guide for Home Economics Teachers, U.S. Dept. of Energy. Prepared by Univ. of Tenn. Environment Center and College of Home Economics, Knoxville, TN, October, 1977.

Food - Energy Conservation

Background:

Processed foods cost energy for preparation, for packaging, and sometimes for storage as well. Some processing is unavoidable, however. Many must be specially preserved for use after the growing season ends. Others must be treated to stay edible during prolonged transportation and storage before reaching consumers. Special packaging that adds to the "energy cost" of some foods may keep out moisture and insects or may be chosen primarily for attractiveness, convenience, and/or familiarity to the consumer.

What can be done to reduce food-related use of energy? Note that typical processed foods usually involve transportation and storage costs, packaging costs, food-chain losses, and additional home-energy use.

The first energy premium, transportation, is reduced whenever fresh produce is grown at home. Even if commercial practices are used in the home garden, about half of the energy cost to put fruits and vegetables on the table is saved by the gardener. If hand-spading, composting and non-chemical pest control practices are used as in "organic" gardening, then even more energy savings are likely.

Avoiding some highly-processed foods, frozen specialties in particular, can also reduce reliance on commercial energy. TV dinners and their packaging, for example, typically take 4.43 KWH* each to process--much more than if individual items were cooked from basic ingredients. By comparison, a 14 ft. standard refrigerator-freezer requires about 3.3 kwh daily for its operation; a microwave oven typically uses 1.5 kw during 60 minutes of operation while a conventional electric oven uses about 3.8 kw during that time.

Packaging is usually a major energy "cost" of bringing food to the consumer. Fast-food restaurants often put multiple wrappings on sandwiches to be eaten immediately. Smaller grocery containers require more packaging material per unit of contents than do larger containers. Paper bags and glass bottles can be reused and metal cans can be recycled, but seldom are. Consumers can help reduce these energy extravagances by buying more bulk and unpackaged foods; by patronizing co-op stores which allow customers to reuse their own bags and containers, by buying beverages in returnable bottles only. (Most soft drinks have two to three times as many Calories invested in the container--not including transportation and cold storage energy consumed--as is contained in its surgary contents.*)

**Data from Energy and Food, by Pierotti, Keeler and Fritsch, Center for Science in the Public Interest, 1977.*

Food-chain losses come with every conversion of energy from one life-form to another. In general, the shorter the chain, the greater the percentage of solar energy is available to the human consumer. Plant protein requires less energy input than does animal protein, so whole grains and legumes (beans, lentils, peas) when substituted for meat or used as meat extenders conserve energy. Milk, cheese, eggs, fish, and poultry require $< 20\%$ of the energy input required for beef cattle to produce the same amount of protein. So more "efficient" eating would usually mean menus low in grain-fed beef, high in vegetable and animal produce substitutes.

Energy costs do not stop when we carry groceries home. In fact, storing and preparing food at home requires more energy than any other single step in the long chain from solar energy to human energy. Ovens, refrigerators, and freezers plus a host of smaller appliances, some of which (coffeemakers and toasters for examples) are high energy consumers, are part of most human kitchens. Their use contributes to the nine to ten Calories of energy spent by U.S. citizens for every Calorie of food put on the table, a record of inefficiency among developed nations.

Resources:

Energy and Food by Pierotti, Keller, and Fritsch, 1977. This technical report on energy used in production, processing, delivery, and marketing of selected food items is available for $6.90 to educators from Citizens' Energy Project, 1110 6th Street NW, #300, Washington, D.C. 20001.

Lifestyle Index by Pierotti and Fritsch, 1977. Text, tables and data sheet provide provocative invitation for individual assessment of energy used in everyday life. Send $2 to Citizens Energy Project, 1110 6th Street NW, #300, Washington, DC 20001.

Diet for a Small Planet by Francis Lappe, a Ballantine paperback cookbook, includes both rationale and recipes for saving energy by eating lower on the food chain.

Current articles in Organic Gardening, Mother Earth News, other magazines with practical living tips.

Activity Suggestions:

1. Try to trace the energy route of today's school lunch, from the sun to the student consumer. How many steps are involved? Can any of them be eliminated?

2. Plan a series of menus involving least-possible energy use to put the food into edible form.

3. Identify the items with highest-energy input on restaurant menus and the items with the least energy and preparation requirements. Consider transportation, storage, packaging, cooking and serving requirements. Can balanced diets be planned by eliminating the most energy-intensive items and increasing use of the least energy-intensive ones?

244

4. Survey your local grocery store with a critical eye. Report your observations in any form that answers the following questions: Which categories of food require the most energy at that site? Is the cost of that energy use within the store reflected in the price of those items? What energy-saving features are incorporated into the design and operation of the store? Can you identify areas needing improvement? What were people buying when you visited the store? (Approximate percentages of purchases for basic fresh foods that need no further energy input; raw foods that must be cooked before eating; processed ready-to-eat foods that require refrigeration and those that do not; processed foods that require heating or cooking before use.)

5. Visit a food co-op or a food discount store. What is different about their groceries, physical facilities, and method of distribution? Identify any energy demands and energy savings in these operations.

6. Plant a vegetable garden; investigate both energy and economic savings by comparing net yields of your produce vs. usual store purchases. Record keeping is important if you hope to make fair comparisons.

7. Explore secondary use possibilities for food packages. What is being done now with the paper, plastics, metals, and glass leftover from food purchased--by individuals at home, by food distributors like your local grocery, by city sanitation crews? What are the alternatives for disposal? Which would be better for conserving energy and other natural resources?

8. Do a controlled experiment on cooking in covered vs. uncovered containers.

9. People in some European countries use thermos bottles to keep coffee hot all day. Americans often rely on uninsulated electric pots or on coffee machines which use about 1.4 kw for every hour of keeping coffee hot.

   Danes are fond of "hay boxes" or tightly insulated bins into which a preheated potful of unfinished stew, soup or pot roast (for examples) can be left simmering for hours, completing cooking without additional energy expense.

   Iced tea lovers the world over have learned that loose tea or tea bags (2 tsp. or 2 bags to a quart) put into a glass container of water will slowly brew into a non-bitter tea. The only extra investment is time--two to three hours of exposure to the Sun will do it, or about 12 hours in a dark corner. The bonuses are in energy savings, costs, and improved flavor.

   The above examples of "passive" energy savers in food preparation. Look through energy publications, home and food magazines, and cookbooks and/or talk to older people in your community to see how many other savers in food preparation you can list. Exchange ideas with classmates. Compile a composit list for the class. Consider publishing such a list for your parents, or in the local newspaper, or by sending your treasury of energy-reducers to a popular home-centered magazine.

Home and Schools' Energy Efficiency

A project to monitor energy use of your school building and compare it to an average one for your area is a very practical and effective teaching device. Not only that, it can involve the community outside the classroom (schoolboard, taxpayers, parents) which is keenly interested in energy economy as well as the entire staff of the school itself.

Such a project involves students in learning some heat transfer theory, making practical measurements, and doing calculations with guidance from the teacher. They can then apply these techniques to an energy assessment of their own homes.

All the facts you need and step-by-step instructions have been published by Dr. Dale Mordue of Mankato State in his booklet, "Energy Conservation: A Classroom or Do-It-Yourself Project." The booklet is available from Dr. Doris Simonis, Science Education, University of Iowa, Iowa City, IA 52242 for $1.25. Or you can mail your request and $1.50 for a postpaid copy from Dr. Dale Mordue, MSU Physics Department, Mankato, MN 56001.

Several Iowa teachers have had experience with Dr. Mordue's program and they may be helpful resource persons for this recommended activity. Their names and locations follow:

W. D. Ackerman, Hoover High School, Des Moines, IA 50310

D. Lester Carter, Pella High School, Pella, IA 50219

Stephen Dikkers, Guttenberg Jr.-Sr. High School, Guttenberg, IA 52052

Donald E. Liefeld, Central Lyon Sr. High School, Rock Rapids, IA 51246

Larry Nelson, Lakota High School, Lakota, IA 50451

Robert G. O'Connell, Wahlert High School, Dubuque, IA 52001

Roger L. Park, Wayne Community High School, Corydon, IA 50060

Glen Peterson, Le Mars High School, Le Mars, IA 51031

Dwight Williamson, Clear Lake High School, Clear Lake, IA 50428

Reading Electric Meters

On some wall of your home--basement, garage, or most often outside--you will find an intricate glass-enclosed device. If you are like most people, you seldom pay any attention to it. Nor do you need to, for modern electric meters perform their job so accurately and reliably that you need never be troubled. But, every month or so, a person from your electric utility company comes to see it, and later you are billed for the exact amount of electricity used.

Meters Measure Electricity. Through your meter's glass enclosure, you can see a revolving aluminum disk and a series of dials and pointers, or digital numbers. Without explanation, they don't make much sense, but they are really quite simple.

The amount of electricity you use determines the speed at which the disk moves. The more electricity you use, the faster it turns. Each revolution represents a portion of an electric energy unit called watt-hour. This watt-hour measurement is transferred from the disk through a series of gears to the digital numbers or pointers on the dials.

Just What Is A Watt-hour? Every hour a 100-watt light bulb burns, it uses 100 watt-hours of electric energy. Since a watt-hour is such a small unit of energy, your electric utility company uses a unit equal to 1,000 watt-hours--a kilowatt-hour--to measure the amount of electricity used.

What Makes Your Meter Disk Turn? There are two sets of connections which cause your meter to register: (1) the amount of current flowing into your house, and (2) the pressure or voltage at which the current is flowing.

Electric current is like water flowing through a pipe. The rate of flow of electrons through a line is measured in amperes. Pressure is the force that pushes electric current through the lines, measured in volts. To determine the electrical power (watts) used, multiply amperes of current by volts of pressure. Your electric bill is stated in kilowatt-hours.

Clock-Like Meter Accuracy. Friction inside the meter is all but eliminated with the use of a magnetic-suspension system which uses a magnetic field to float the disk and its shaft in air. To help maintain accuracy provided by magnetic suspension and other design features, the meter is sealed with filters which keep its interior free of dust and other contaminants which can cause inaccurate meter registration.

This student activity was taken from Environmental Education Strategies for Wise Use of Energy, Division of Science Education, North Carolina Department of Public Instruction, February, 1974.

Your Meter--A Small Motor. Your meter is basically a small induction motor run by magnetic forces created by electricity in a set of coils. The voltage coil is a winding of wire connected to the power supply lines. The current coil is a winding of wire connected with the household wiring. When current passes through these coils, the disk is forced to turn at a speed exactly proportional to the number of watts (amps x volts) of electrical power being used.

Meter Progress To Meet Your Needs. Meters have changed a great deal in the last 20 years. They have had to. Television, electric heating, more lights, freezers, air conditioners, water heaters, and other new appliances have more than quadrupled the average family's consumption of electric power. Twenty years ago a meter rated at 600 watts was enough to meet average household requirements. Today's meters are capable of handling up to 48,000 watts.

How To Read Your Kilowatt-Hour Meter. The kilowatt-hour meter is an instrument used to measure electrical energy consumed by a customer.

Two types of meters used by the power companies are the digital- and dial-type meters. The digital meter is read directly from left to right as shown in Figure 1. Readings on some digital meters are obtained by multiplying by ten.

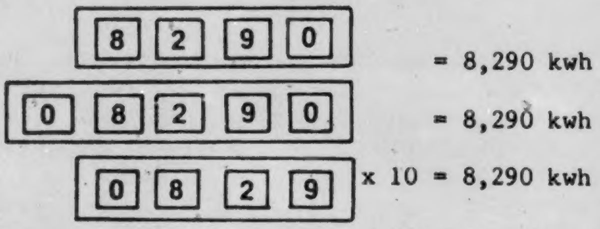


Figure I - Digital Kilowatt-Hour Meters

Most meters have four or five dials (see Figure II). The figure above each of the dials indicate the number of kilowatt-hours (kwh) registered by the meter during the time that the hand on that dial makes one complete revolution. So, when the hand on the right-hand dial has passed from one figure to the next, 1/10 of 10 kwh, or 1 kwh, has been used.

Be sure to read the meter "backwards"--from right to left--and remember to read the smaller of the two numbers between which the pointer on the dial is standing. This is very important.

Note that the pointers of the 10 and 1,000 dials rotate clockwise and counterclockwise on the 100 and 10,000 dials. During the time that the pointer on any one dial is making a complete revolution from 0 to 0, the pointer on the next dial to the left will pass from one figure to the next. Therefore, although a pointer on one dial may appear to have arrived on a given figure, that figure should not be read unless the pointer on the dial to the right has reached or passed 0.

For example, in Figure II, the pointer on the 1,000 dial looks as if it is on the 5, but you should read that dial "4" because the pointer on the 100 dial, to the right, has not made a complete revolution to 0. The correct reading is shown under the dials.

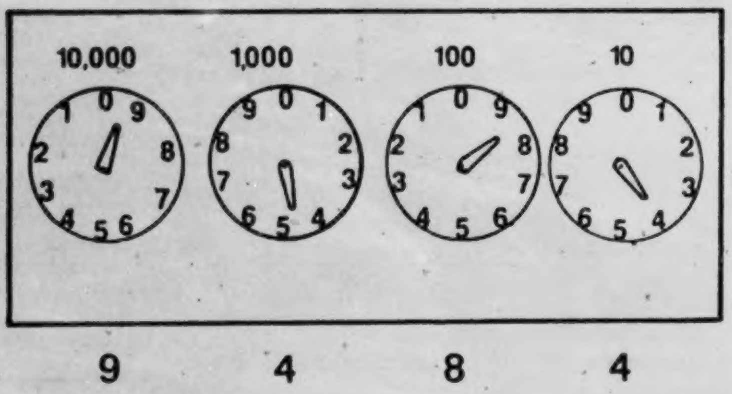

10,000
1,000
100
10
9
4
8
4

Figure II - Dial Kilowatt-Hour Meter

Kilowatt-Hour Record

(Student Activity Sheet)

Read your kilowatt-hour meter at home and record the reading. A. ____________

Read one week later and record the reading. B. ____________

Subtract B from A to determine kwh used during the 1st week of your experiment. C. ____________

During the 2nd week, encourage your family to conserve all the electricity possible. At the end of your 2nd week, again read the meter and record. D. ____________

Subtract D from B to determine kwh used during the 2nd week of your experiment. E. ____________

Subtract E from C to determine how much electric energy your family saved over the previous week. F. ____________

1. Were you successful or did you use more electricity?

2. If you used more, can you explain why?

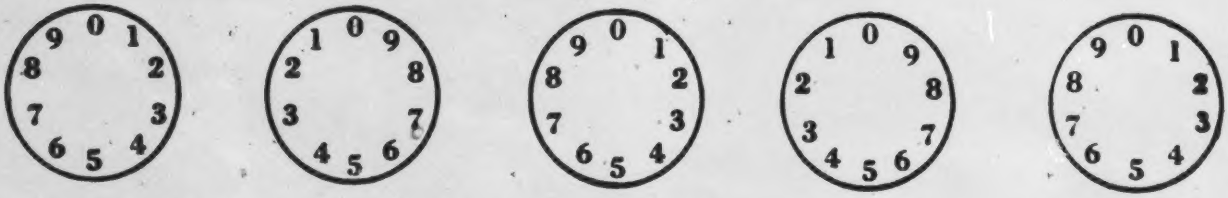
3. Why would someone with an electrically-heated home have to consider the temperature during the two weeks?

4. List all the energy-saving steps your family took.

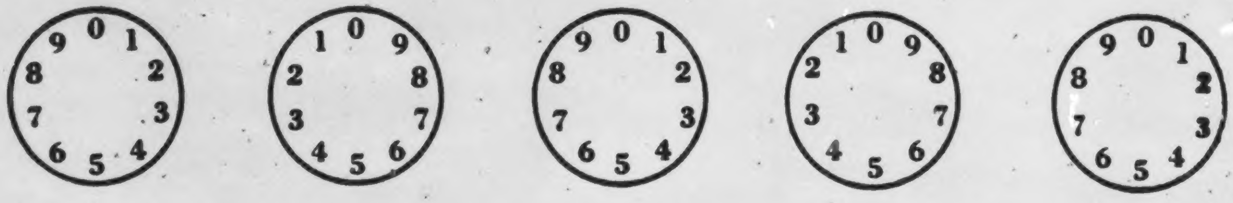
250

HOW MUCH GAS OR ELECTRICITY DO WE USE?

Name ______________________________

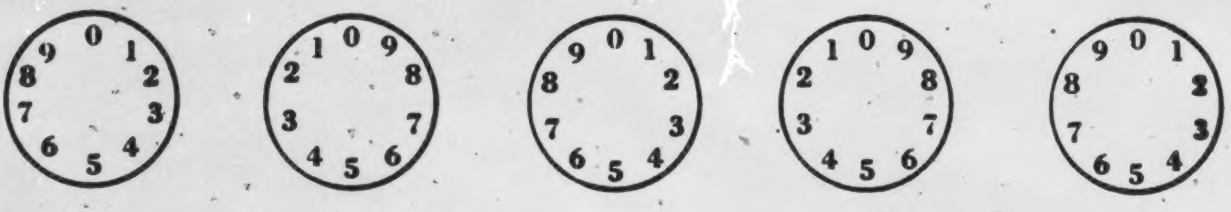


Date __________ **Time** _________ **READING** __________________

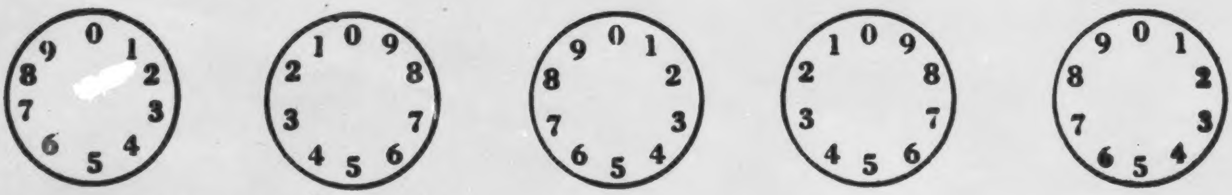


Date __________ **Time** _________ **READING** __________________

TRY TO SAVE ENERGY!



Date __________ **Time** _________ **READING** __________________



Date __________ **Time** _________ **READING** __________________

How Much Electricity Appliances Use

The following data are based on normal usage of appliances named.

Appliance	Average Wattage	Estimated Kilowatt Hours Consumed Annually
Food Preparation		
Blender	300	1
Broiler	1,140	85
Carving Knife	92	8
Coffee Maker	894	106
Deep Fryer	1,448	83
Dishwasher	1,2[illegible]	363
Egg Cooker	5[illegible]	14
Frying Pan	1,196	100
Hot Plate	1,200	90
Mixer	127	2
Oven, Microwave (only)	1,450	190
Range		
with oven	12,200	1,175
with self-cleaning oven	12,200	1,205
Roaster	1,333	60
Sandwich Grill	1,161	33
Toaster	1,146	39
Trash Compactor	400	50
Waffle Iron	1,200	20
Waste Dispenser	445	7
Food Preservation		
Freezer (15-21 cu. ft.)		
chest type, manual defrost	*	1,320
upright type		
manual defrost	*	1,320
automatic defrost	*	1,985
Refrigerators/Freezers		
manual defrost, 10-15 cu. ft.	*	700
automatic defrost, 16-18 cu. ft.	*	1,795
automatic defrost, 20 cu. ft. & up	*	1,895
Laundry		
Clothes Dryer	4,856	993
Iron (hand)	1,100	60
Washing Machine (automatic)	512	103
Washing Machine (non-automatic)	286	76
Water Heater	2,475	4,219
(quick-recovery)	4,474	4,811

Appliance	Average Wattage	Estimated Kilowatt Hours Consumed Annually
Comfort Conditioning		
Air Cleaner	50	216
Air Conditioner (room)	860	860**
Bed Covering	177	147
Dehumidifier	257	377
Fan (attic)	370	291
Fan (circulating)	88	43
Fan (rollaway)	171	138
Fan (window)	200	170
Heater (portable)	1,322	176
Heating Pad	65	10
Humidifier	177	163
Health & Beauty		
Germicidal Lamp	20	141
Hair Dryer	381	14
Heat Lamp (infrared)	250	13
Shaver	15	0.5
Sun Lamp	279	16
Tooth Brush	1.1	1.0
Vibrator	40	2
Home Entertainment		
Radio	71	86
Radio/Record Player	109	109
Television		
black & white		
tube type	100	220
solid state	45	100
color		
tube type	240	528
solid state	145	320
Housewares		
Clock	2	17
Floor Polisher	305	15
Sewing Machine	75	11
Vacuum Cleaner	630	46

**Figures not available.*

***Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit.*

Source: Edison Electric Institute

Teacher's Guide to Reading Electric Meters

The purpose of having students learn to read electric meters to to give them an opportunity to practice conservation and to see the results as measured by a meter.

The activity calls for three meter readings over two weeks' time. It may be more practical to ask for daily readings made at the same hour each time. This would provide more practice and an accurate record for comparing daily usage, such as weekdays vs. weekends.

You may wish to ask the local power company whether it could provide a used meter for demonstrations. Or you may ask the school custodian to show you where the building's meters are and, if the location is convenient, use them for examples and for readings also.

A student activity sheet and a sample worksheet showing meter dials have been included for your convenience. The blank dials can be used for practice or for test items.

Key concepts to be emphasized in this activity are:

1. A kilowatt is a measure of electricity; it is 1000 watts of electricity; it is the amount of electricity used by lighting ten 100 watt bulbs for one hour.
2. Conservation efforts have measurable effects on consumption.
3. Reduced consumption means savings on utility bills.
4. What people do makes a difference. Rate of use of energy resources will determine how long supplies last.

Extended Activity:

This energy lesson can be extended to include reading gas meters and fuel oil bills and to keeping tract of gasoline purchases. Students may then be able to total their direct home or school use (per day or per month) of commercially-supplied energy. Some conversions may be necessary in order to make figures comparable:

Natural gas--cu. ft./day x 260 Calories/cu. ft. = Cal/day
(based on typical content 1,030 BTU/cu. ft.)

Fuel Oil--gal/day x 34,000 Cal/gal = Cal/day
—barrels/day x 1,400,000 Cal/bbl = Cal/day

Gasoline--gal/day x 32,000 Cal/gal = Cal/day

Electricity--kwh/day x 860 Cal/kwh = Cal/day

Going a step further, recognize that getting energy to the home also costs energy. Mining, refining, and transporting fuels also requires energy use. You can approximately account for that cost by multiplying natural gas, fuel oil, and gasoline Cal/day x 1.1 to get a new Cal/day total.

Electricity generated from fossil or nuclear fuels is more fuel-expensive to produce than are primary energy sources. For every three units of fuel burned, only one unit of electricity is realized; the balance is released as waste heat. To approximate the system input for the electric Cal/day, multiply the figure times three.

Then to calculate per-person share of this Calorific total, divide by number of persons in the household (or number of students in the school, if school records are used).

Consider other ways people use energy that do not show up on their home utility bills (manufacturing costs of cars, appliances, food processing, medicines, newspapers; services of doctors, repair persons, police, and military; all construction; transportation systems to distribute manufactured goods and agricultural products; use of laundromats, hospitals, shopping malls, offices, etc.) There is a difficult-to-qualify additional daily sum of energy used per person that raises the U.S. per capita daily average to more than 220,000 Calories/day.

Compare students' calculated energy consumption with those stated on the table of Energy Consumption Per Capita in 1976 for Selected Countries. Challenge them to explain the great differences between various countries. You may want to assign each student a particular country for further investigation. Ask for reports on kinds of employment, population, size of largest city, chances for education, longevity, food situation, cultural development, transportation systems, world trade, pollution problems, and any other aspects of national life that may possibly relate to energy use.

Helpful Resources:

The Household Energy Game, $.15 cents each from Sea Grant College Program, University of Wisconsin, Madison, WI 53706

Ritsch and Castleman's Lifestyle Index '77, including charts for adding up individual energy consumption, $2.00 from Citizen's Energy Project, 1110 6th Street, NW, #300, Washington, DC 20001

Pamphlets on meter reading and typical energy requirements of appliances, free from your local utility company.

Iowa-Illinois Gas and Electric Company has a "watt-watcher" you can borrow for classroom use. The meter can monitor household appliances rated <1,000 watts (this excludes 200 volt ranges and air-conditioners). The read-out is in dollars. The meter is pre-set at current electric rates. Arrangements for this customer service can be made through Mr. Fred Maihack, Iowa City office, (319) 338-9781.

Energy Consumption Per Capita in 1976

For Selected Countries

Area	Country	Annual Per Person Consumption in kgce[a]	Equivalent[b] Calories/person/day
World:	All	2,069	39,600
Africa:	Egypt	473	9,000
	Ethiopia	27	500
	Kenya	152	2,900
	Nigeria	94	1,800
	South Africa	2,985	57,300
N. America:	Canada	9,950	190,800
	United States	11,554	221,600
	Mexico	1,227	23,600
S. America:	Argentina	1,804	34,600
	Brazil	731	14,000
	Paraguay	189	3,600
	Peru	642	12,300
Middle East:	Iran	1,490	28,600
	Israel	2,541	48,700
	Lebanon	533	10,200
	Turkey	743	14,200
Asia:	China	706	13,500
	India	218	4,200
	Japan	3,679	70,600
	Korea	1,020	19,600

Area	Country	Annual Per Person Consumption in kgce[a]	Equivalent[b] Calories/person/day
Asia (cont'd):	Napel	11	210
	Philippines	329	6,300
	Viet Nam	124	2,400
Europe:	Austria	4,013	77,000
	France	4,380	84,000
	W. Germany	5,922	113,600
	Greece	2,250	43,200
	Ireland	3,170	60,800
	Italy	3,284	63,000
	Netherlands	6,224	119,400
	Norway	5,263	101,000
	Portugal	1,050	20,100
	Spain	2,399	46,000
	Sweden	6,046	116,000
	Switzerland	3,340	64,100
	United Kingdom	5,268	101,000
	U.S.S.R.	5,259	100,900
Oceania:	Australia	6,657	127,700
	Fiji	403	7,700
	New Zealand	3,617	69,400
	Samoa	160	3,100

---

[a] *Data are from the 1977 Statistical Yearbook, United Nations, New York, New York. Consumption is based on apparent consumption of coal, peat, lignite, petroleum products, natural gas, and hydro- and nuclear-electricity. Wood and food are not included.*

[b] *The unit of consumption stated by the United Nations is kg coal equivalents per person. The calories/person/day figures are derived on the basis of one coal equivalent = 7,000 calories/gram, or 7,000 Calories/kg.*

PAGES 429-432 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

Typical Energy Requirement of People-Movers in 1972*

Within Cities	BTU/passenger mile
bicycle	200
walking	800
commuter train	2,600
bus	3,000
automobile	6,700

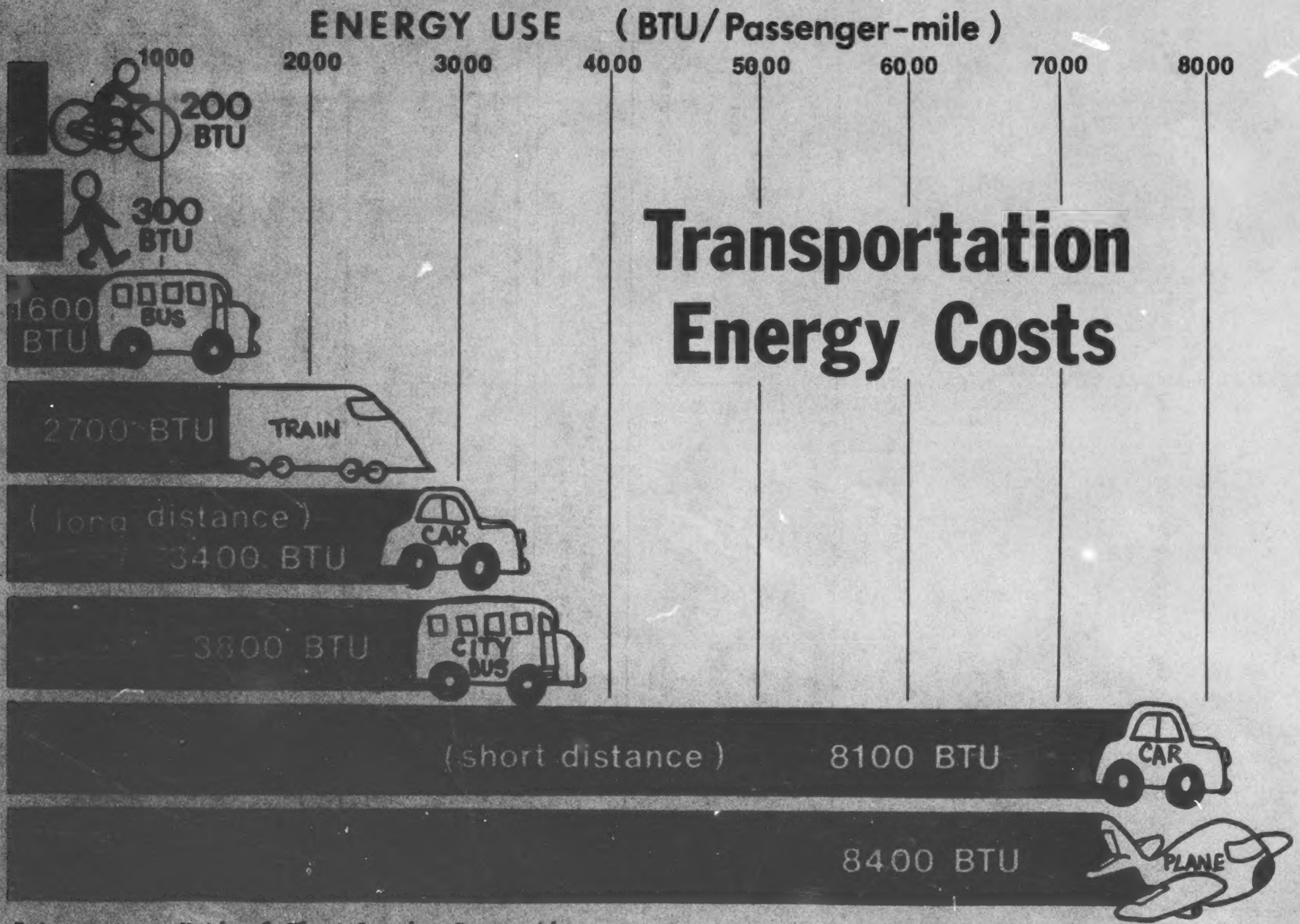
Between Cities	BTU/passenger mile
bus	1,500
train	2,700
automobile	3,100
plane	7,700

Average Energy Cost of Freight Transportation

Method	BTU/ton/mile
pipelines	450
trains	670
ships, barges	680
trucks	2,800
airplanes	42,000

*from Eric Hirst, "Policies to Reduce Transportation Fuel Use," Oak Ridge National Laboratory, November 3, 1975.

Transportation Energy Costs



Data source: National Fleet Leasing Corporation

Window Cover Project

Introduction:

Windows are heat exchangers. They conduct heat much faster than walls do. The resistance to heat transfer (R-value) of a single pane of glass is about 0.9. A second pane nearly doubles that value. However, compared to an exterior wall insulated to the recommended minimum of R-19, a double paned window exchanges ten times more heat.

During sunny winter days, windows that allow sunlight to enter can help heat the building for a few hours. Sunlight means warmth as well as less need for artificial light sources. But during the long periods of winter darkness, buildings lose considerable heat through windows, adding to the cost of maintaining interior warmth.

Why can't a window be a wall part of the day or part of the year (depending on its location and uses)? Thermal shutters, specially constructed shades, or sliding wall panels can be used to insulate windows from the inside of a building. Another alternative is a basic movable cover or "lid" you can make for a problem window.

Objective:

To build, decorate, and install an insulating window cover.

Materials:

One 4' x 8' sheet of 1" rigid styrofoam insulation
∼ 30 lineal feet of wood lattice, 1 1/8" x 1/4"
2 plain cabinet knobs with screws or 2 screw eyes
Elmer's glue
One of the following: decorative fabric, wallpaper, foil, cork, 1/4" plywood, or latex paint
∼ 30 lineal feet of weatherstripping

Tools:

Pencil and paper
Steel measuring tape or carpenter's rule
Utility knife
Hand saw
Staple gun
Mitre box (optional)

Directions:

1. Carefully measure the inside casing of the window to be fitted with an insulating cover. Record the height, the top width, and the bottom width. If the width measurements differ by greater than 1/8", you should make a paper or cardboard pattern of this non-standard opening before proceeding.

2. Subtract 1/8" from both the width and the height.

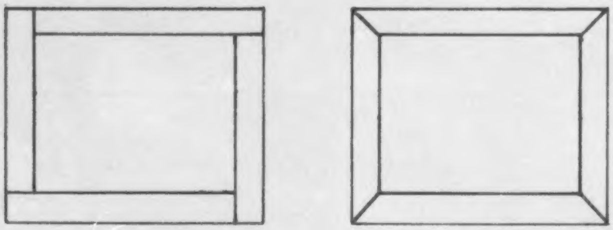
3. Using the adjusted width and height measurements, mark off in pencil the panel to be cut from the styrofoam sheet. Or, if you have made and trimmed a pattern, pin it to the styrofoam as a guide.

4. Hold the styrofoam sheet steady while you carefully cut out the panel with the utility knife. Score the styrofoam lightly in the first cut. Increase pressure on succeeding cuts until you cut all the way through.

5. Check your panel against the window for closeness of fit. Trim only if necessary because a tight fit is essential. You will find slight "give" in the material that will compensate for slight imperfections.

6. Cut the lattice strips with a hand saw to make a wooden frame for the panel. Start with exact dimensions of your cut piece and then make one of the following:

FRAME OPTIONS:



a. Box frame - Each piece is the width or length of the panel less the 1 1/8" of the lattice. Glue the frame to the panel first, then staple each joint twice.

b. Miltred frame - Each piece is the width or length of the panel. Ends are cut 45° with a mitre box. Glue frame to the panel, then staple each corner twice.

7. Consider the framed side of your panel the "outside": it will face the window. Now decorate at least the "inside" or room-facing area of your window cover. You may glue foil or cork to the room-face side. Or you may choose fabric or wallpaper to cover your panel. If so, allow a 5" margin over both length and width dimensions. Cover edges of your panel and staple the material to the wooden frame in back. You can also paint your window cover by brushing on latex paint. Or you may prefer to cover the panel with a plywood face. If so, frame both sides and then glue the plywood to the room-side face.

8. Add knobs or screw-eyes (for pulls) last. Put one on opposite ends of the room-facing side, in a convenient position for pushing on and pulling off the panel. If your window is small (about four square feet or less in area), one center knob is probably enough.

9. Apply weatherstripping around the window casing. This will help prevent infiltration.

10. Install the window cover. It should press tightly against the weatherstripping when in place. Yet it is lightweight and easy to remove whenever desired.

Extended Activity:

Answer the following questions. You may want to use the resources of your local library for ideas to incorporate in some of the responses.

1. Is window insulation important only in winter? Explain.

2. Why is window covering especially desirable at night?

3. What changes in decorative details would make this kind of window insulation more attractive to the eye?

4. Suggest another design, material, method of installation, or storage technique that would make window covers more acceptable to American consumers.

5. Inside window covers have been suggested for existing buildings in particular, where opportunities for major structural changes are limited. They are an add-on or retrofit strategy. Find out about other retrofits and suggest one that would make your home or school more comfortable while using less energy than before.

6. If you were building a new home or school this year, all done to your specifications, what features would you include in order to avoid excessive heat transfer by windows?

Teacher's Guide to Window Cover Project

Time Required:

To complete the basic construction project at least two class periods (45-50 min. each) are needed. Plan ahead. Either have student pre-measure a window at home, or you identify windows within the school building that are accessible and would benefit from insulation.

CAUTION: Note that styrofoam should not be used near flame or in areas that are likely to get unusually warm (greater than 160° F).

Basic Costs:

Exact cost is difficult to figure, but it's at least $1 per square foot (at 1980 prices) for the basic, undecorated, single panel. In June 1980, a 1" thick, Dow extra-strength styrofoam panel cost $11.15 in Davenport, IA; the lattice cost $.11 per lineal foot; sturdy screw eyes were $.07 each while conventional pulls were greater than $1; self-adhesive rolled foam weatherstripping tape cost $.05 to $.15 per lineal foot, price depending on width of material.

Whether one or eight window covers can be cut out of each sheet of styrofoam depends on the size of the windows. Whether all 32 square feet of material per sheet is used is problematic also; usually there will be plenty of scraps.

Insulating Value

The R-value or resistance to heat transfer will depend on the R-value of the rigid insulation used plus the R-value of the decorating material.

For one example, Dow extra-strength styrofoam in 1" thick sheets has an R-value of 5.4 at 40°F. If your target window has a deep enough frame to accommodate a 2 1/4" window cover, you can double the effectiveness of the basic insulation. Cut a duplicate panel and glue it to the outside-frame of the original cover. You now have a styrofoam sandwich with a wood and air filling. Even without any additional insulation from material added to decorate the face, this thicker cover would have an R-value of 11.

Design Alternatives for Rigid Panels:

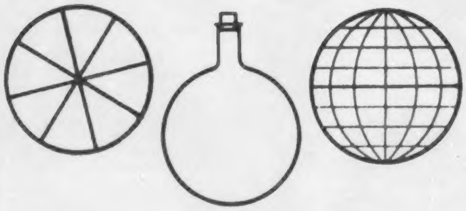
Magnets along the window casing attracting opposing magnets inserted in the edges of the styrofoam are a feature suggested in popular magazines.

Wooden channels on the ledge in front of windows would permit sliding panels.

Door tracks on a ceiling could support wood-encased panels for whole-wall coverage in some situations.

Carefully hinged and weatherstripped folding screens might be appropriate to cover large windows; they'd be less awkward to store than a bulky, totally rigid cover.

Side-hinges only or folding-shutter hardware for hanging insulating panels permanently on the wall solve a storage problem, but this alternative is not feasible for all types of windows and it does increase costs.



Energy Converters and Power

Time is involved in most considerations of energy flows. Power means the energy available per unit of time--for example, so many calories per second or Joules per second or watts are common units of power.* Low-energy flows (from a low-powered mover or machine) can sometimes do the same job as a high-energy flow if time is not a critical factor.

Each of the movers listed below converts energy (food or fuel or a natural force) to power.

Power Output of Selected Energy-Converters

Basic Converter	Typical Power Output (in kilowatts)
Man	0.1
Ox	0.2
Horse	0.5
Windmill	15.
Waterwheel	300.
Steam engine	2,000.
Internal combustion engine	10,000.
Gas turbine	80,000.
Water turbine	100,000.
Steam turbine	1,000,000.
Liquid fuel rocket	16,000,000.

*The watt is a unit of energy per unit of time. One watt is one joule per second or 0.239 calories per second or .0002 Calories per second. Human metabolism converts chemical energy at a rate of approximately 100 watts, or 0.1 kilowatts.

Teacher's Guide to Energy Converters and Power

There are many ways to use the information on ENERGY CONVERTERS AND POWER with your class. Some involve math; some develop a sense of scale useful in art, science, and history; some require getting additional information and/or making value decisions. Choose one or more that suits you and the subject you teach.

Mathematics:

1. Calculate some differences in the power outputs of various converters. For example, how much more energy per second (power) is released by a rocket than by a man?

   (16,000,000 ÷ 0.1 = 160,000,000)

2. How much more powerful is a steam turbine than a steam engine?

   (1,000,000 ÷ 2,000 = 500)

3. Convert all the power ratings to "powers of 10."

Energy-Converter Chart
expressed in powers of 10

Man	1×10^{-1}	kilowatts, power output
Ox	2×10^{-1}	kilowatts, power output
Horse	5×10^{-1}	kilowatts, power output
Windmill	1.5×10^{1}	kilowatts, power output
Waterwheel	3.0×10^{2}	kilowatts, power output
Steam engine	2.0×10^{3}	kilowatts, power output
Int. comb. engine	1.0×10^{4}	kilowatts, power output
Gas turbine	8.0×10^{4}	kilowatts, power output
Water turbine	1.0×10^{5}	kilowatts, power output
Steam turbine	1.0×10^{6}	kilowatts, power output
Rocket	1.6×10^{7}	kilowatts, power output

4. Each "power of ten" is often called "one order of magnitude" in scientific literature. How many orders of magnitude are there from man's power output to the rocket blast?

   (Eight. Don't forget a place for 10^{0} between 10^{-1} and 10^{1}.)

Graphics:

Make a histogram, pictograph, or other scalar method of the comparisons listed on the Energy Converter table. Suggestions follow:

1. Use an adding machine tape to block out proportional areas related to power. One full tape may be used for a cooperative effort OR give each student a piece of adding machine paper about 4 yds. or 4 m long OR make your own long sheets of paper by taping pieces together OR use discarded runs of computer paper.

   A practical ratio to use is 1 mm^2 per unit of human power or 0.1 kw. Then the ox's output can be represented by a rectangle 1 x 2 mm; the horse, by a rectangle 1 or 5 mm; the windmill, 3 x 5 mm; the waterwheel, 8 x 375 mm or 6 x 500 mm or 10 x 300 mm, etc., depending on dimensions of your paper; the steam engine, by a rectangle 8 x 2500 mm or 5 x 4000 mm, and so on. This sort of two-dimensional model dramatically illustrates the power ratios between various converters . . . but you'll only get as far as steam power on a short length (4 m or 4 yds.) of paper. If you've opted for individual efforts, then, when realization dawns that there's not enough room to complete the model, ask how many of the individual strips put together would be needed to represent the internal combustion engine, the gas turbine, the water turbine, etc.

2. If you have use of balance scales and about 3 pounds of clay, make models of the orders and magnitude (powers of 10) on the basis of 1 g clay vs. 10 g clay vs. 100 g clay vs. 1,000 g clay. (You can go to 10,000 g if you have it, but the later stage alone would require 22 lbs. of clay.)

3. Make a step-wise illustration showing power relationships of the converters on a scale representing the orders of magnitude (powers of 10) of their differences. This cannot be a true graph because the power sources are not related entities (see example).

   OR, make a historical power grid, using the same orders of magnitude (suggested above) on the vertical scale, but putting historical time (perhaps also expressed in powers of 10 as "years ago"?) on the horizontal scale. The data provided on the Energy Calendar in this book will be helpful for this approach. You may have to check an encyclopedia for some dates.

4. Using a compass and protractor, make a circular pictograph of the representative fractions of "energy output." Each named component would represent a segment of the total energy outputs mentioned in the original data chart. Based on the sum of 17,192,315.8 kw or 17.2 x 10^6 kw in a 360° circle, each degree would represent 47.8 x 10^3 kw (or, each million kw would be represented by 360° ÷ 17.2 million kw = 20.9°). Thus the major portion of the energy released is represented by the modern rocket (334°), the steam engine is a wedge of 20.9°, and all others are included in the remainder. (See example provided.)

Questions, Thinklers, Discussion Topics:

1. Find out how the historical progression in energy use correlates with the escalation in power outputs. When did waterwheels come into use, for example--before or after windmills? Which turbine is the newest? Attempt to date and put in chronological order all of the basic converters listed on the chart.

2. Consider the INPUT for each basic converter.

   a. What is the origin (fuel or force) of its energy?
   b. Is this INPUT available (renewable) on a human time scale?

3. Does the rate of INPUT match the rate of OUTPUT? (Keep in mind the "one-second" time scale.)

4. What is the useful lifetime of each converter? Do you find any examples of "tortoises" and "hares"?

5. What kind of work would each converter ordinarily do?

6. Which of these converters have contributed to your present standard of living?

7. Which of them can you most easily live without?

8. Which of them are essential to your survival?

9. Can humankind ever have "too much" power?

Role Playing-Simulation:

Assign each student one of the "converters" to research. Ask the student to use the library to find out the history and development of that particular energy converter: fuel requirements for it; nature, quality and importance of the work by this converter (past, present, future?); environmental effects; and social feedbacks from use of this converter.

Based on the information gained in the above assignment, have each student show his knowledge of the particular converter by:

Writing advertising copy or preparing a radio commercial extolling its virtues;

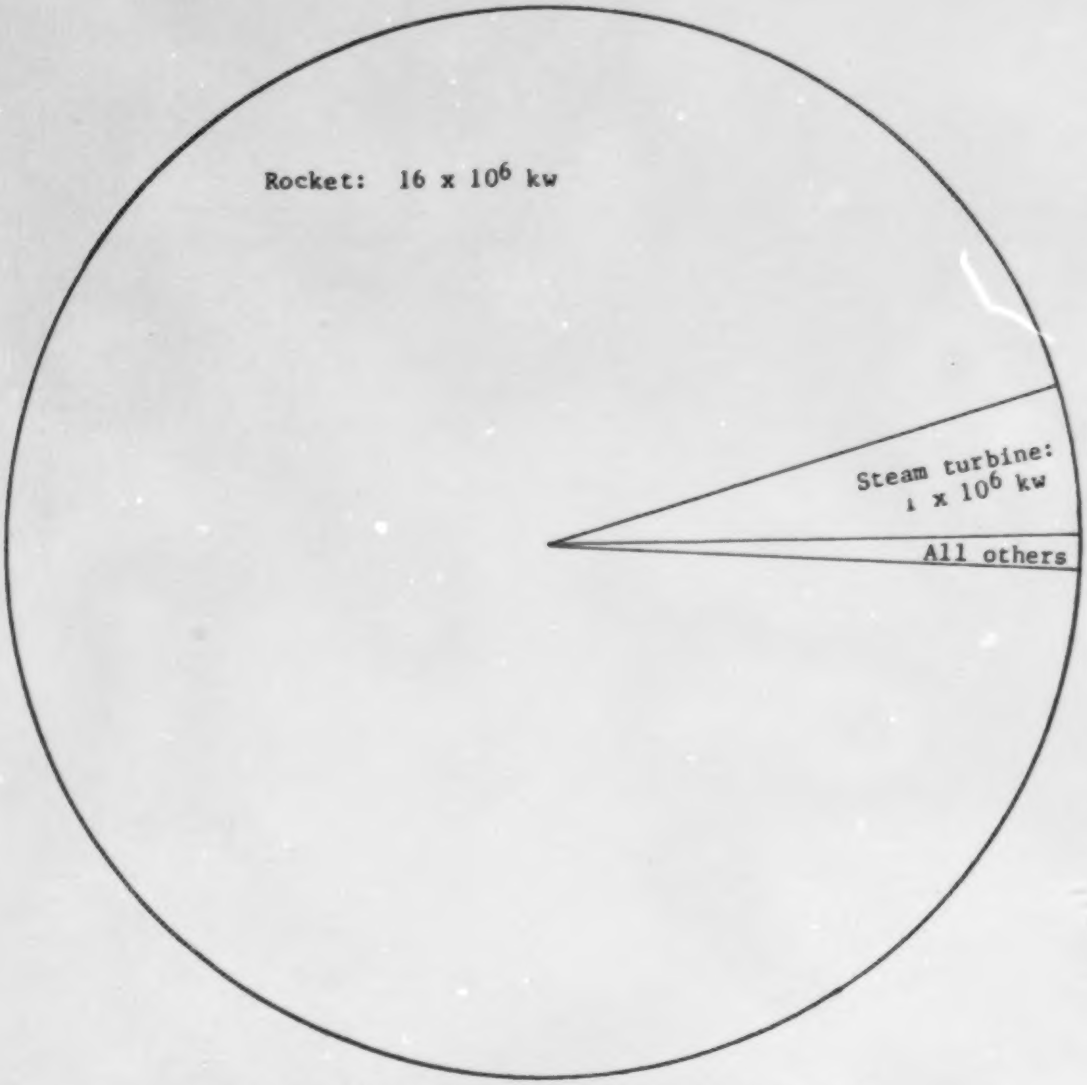
Considering what kind(s) of insurance coverage it would need to protect itself from liability claims; what are its particular hazards?

Explaining how it does (or doesn't) relate to other energy converters.

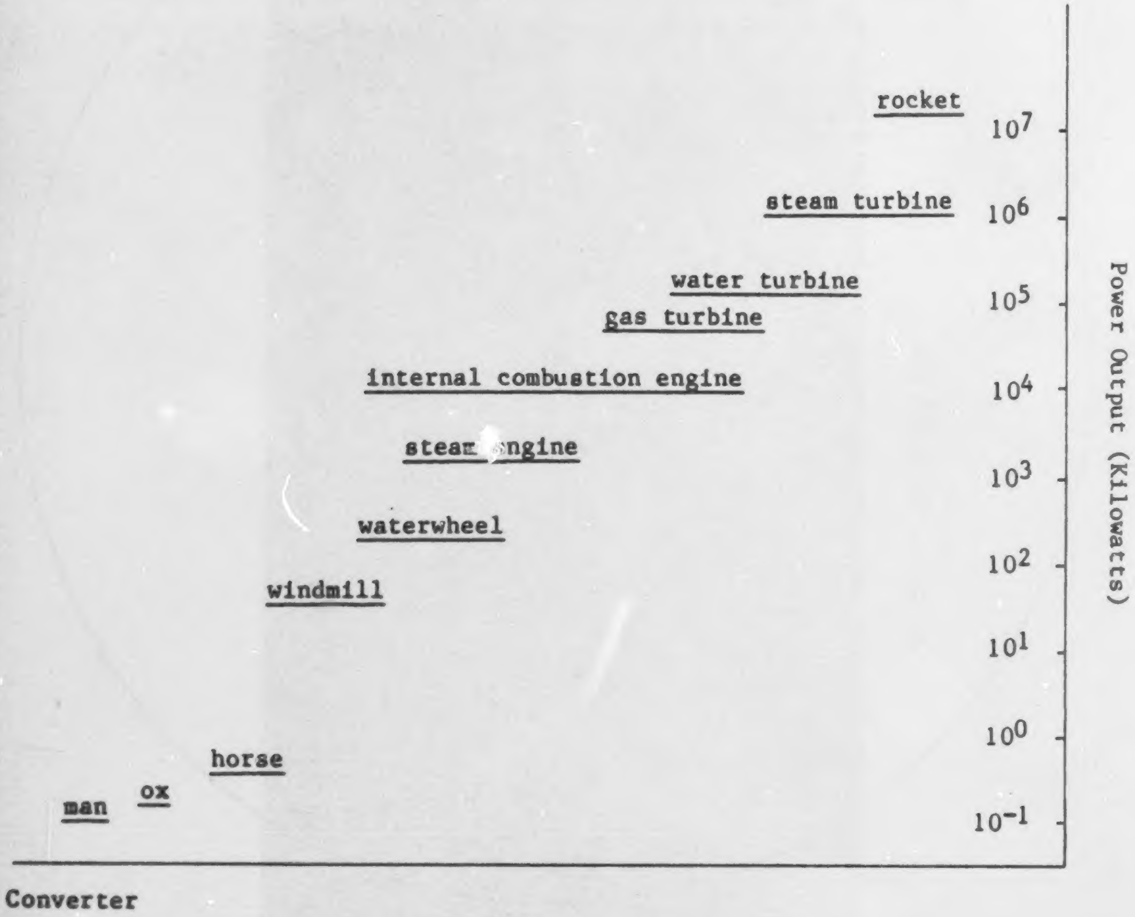
Or assign two students to each converter, one to research its advantages and one to look into its limitations. Have each prepare a three minute report. Then put each converter "on trial" for a few minutes. Have one student present his "case" for allowing this converter to escape the "death penalty." Then have the second student present his objections to continued use of this particular machine. Let the class "vote" on the merits of their arguments. If the "cases" are well-prepared, many "hung juries" are likely.

ONE-SECOND TIME MACHINE

(model of energy output in kilowatts)



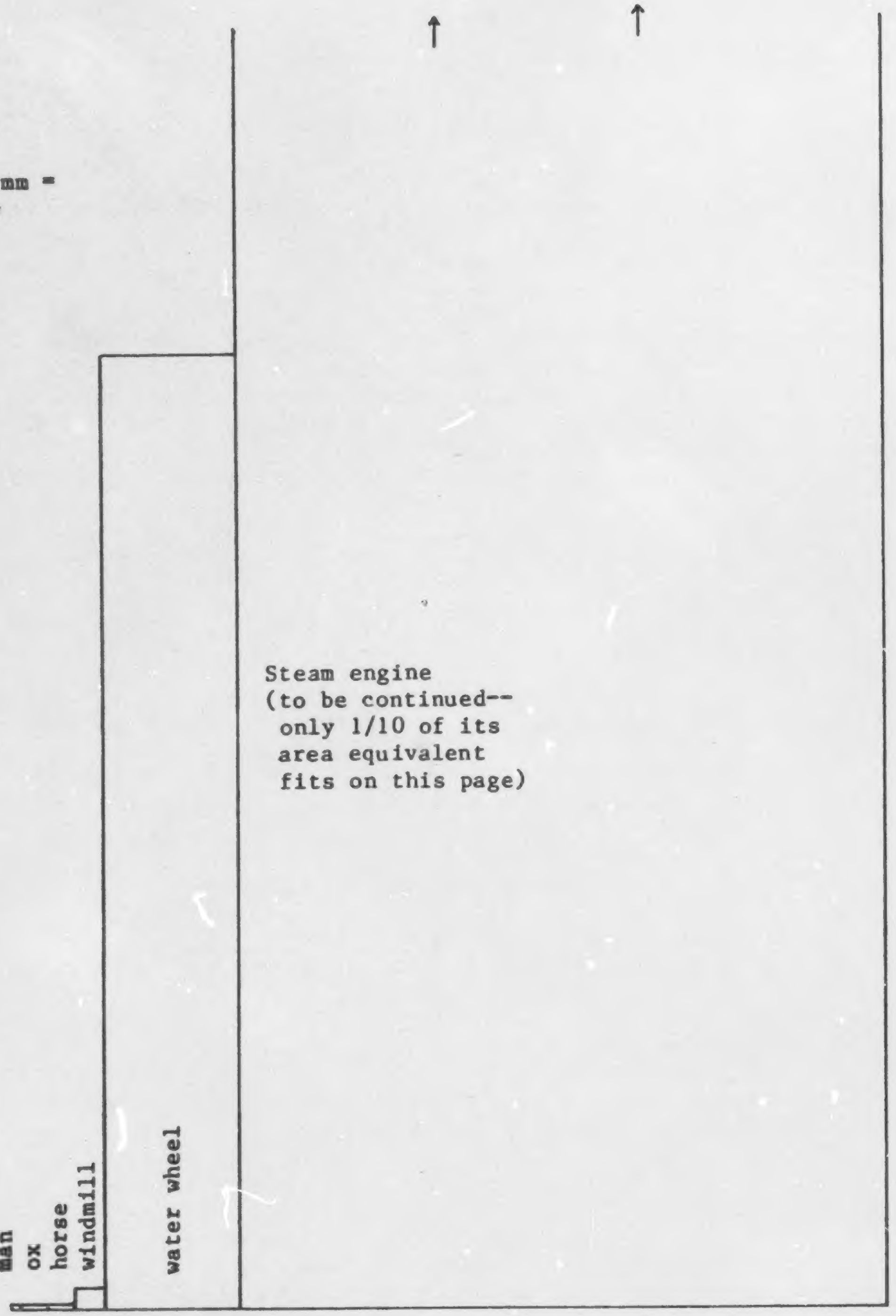
Non-exact model for possible graphic presentation of Table on "Power Output of Selected Energy Converters"



Typical Power Output of Some Energy-Converters

Scale:

1 sq. mm =
0.1 kw



Example of Area-to-Power Graphic

AN ENERGY CALENDAR

Birthday of planet Earth was 4.5 billion years ago.

Oldest known rocks are 3.3 billion years old.
First plants (algae) appeared 3.2 billion years ago.

First known animals (jellyfish) died 1.2 billion years ago.
Fossils first became abundant 600 million years ago.

Age of fishes began 400 million years ago.
Fern-like plants grew densely, became basis of COAL, 300 million years ago.

First dinosaurs thrived 225 million years ago.
First mammals appeared 200 million years ago.

Decline of dinosaurs occurred about 135 million years ago. Along with fossil plants, some became fossil soup (PETROLEUM).
First primates trapped in a fossil record lived 70 million years ago.

Man-like creatures appeared about 3 million years ago.
Ice Ages began 1.7 million (1,700,000) years ago.

Man began to use fire, 500,000 B.C.
Last glaciers retreated, 8000 B.C.

Man learned to smelt metal and make bronze, 3000 B.C.
Iron technology was begun, 1000 B.C.

Waterwheels were used in Greece, 300 B.C.
Book by Vitruvius describes watermills, steam jets, and other machines, 27 B.C.

Mt. Vesuvius destroys Pompeii, 79 A.D.
Waterwheels come to Europe, 500 A.D.

First windmills were used 650 A.D.
Coal was burned in an English monastery, 852 A.D.

Whale oil came into use for lighting, 900 A.D.
Coal was regularly used for home heating in Newcastle, England, 1300 A.D.

Windmills started to drain the Netherlands, 1500 A.D.
Modern steam engine was conceived by Watt, 1765.

First lighting was provided to a small area of New York City, 1882.
Becquerel discovered radioactivity, 1896.

Wright brothers flew the first successful airplane, 1903.
First jet plane flew, 1942.

First nuclear explosions were detonated in 1945.
First nuclear electric power plant in the U.S. was completed, 1958.

Man first walked on the moon in 1969.
"Energy Crisis" of limited supplies and higher fuel prices became a public concern in the winter of 1973-74.

Now--?

Energy Use and Decision Making

Objective:

This multidisciplinary activity provides students an opportunity to simulate the fact finding and decision-making process exercised in making choices about energy use.

Directions:

Let students select one or more of the Energy Use Situations prepared for this activity. Situations should be considered as though they are occurring in the local community. Responses should be defendable. Students may need to do some library research or to contact local professionals for more information so that they have several reasons for their choices and are aware of other possible perspectives as well. Require students to write reports of choices made (maybe in the form of an editorial for the school paper or a "letter to the editor" of the local newspaper), stage classroom debates, or conduct a consensus-seeking discussion.

Whichever technique you use, also consider exploring choices further via a Futures Wheel (in TRENDS AND CONSEQUENCES), as described elsewhere in this publication.

Energy Use Situations:

1. Assume that you are a local celebrity whom people like to imitate. If your position makes it possible to influence energy use habits in your community, then:
    a. Would you limit energy use? In what ways? Why?
    b. What are the most important human factors you would have to consider?
    c. What provisions would you make for the elderly on small pensions? the unemployed? the sick?
    d. What special consideration (if any) would you give to jails, schools, office buildings, hospitals, indoor sports facilities, theaters, restaurants?
    e. How would you (or would you) make exceptions for emergency needs without appearing inconsistent?
    f. Would you personally adopt an unpopular measure (example: no air conditioning for your home and car) at the risk of losing your popularity and influence?

Acknowledgement: This activity, adapted from one included in Ideas and Activities for Teaching Energy Conservation: Grades 7-12, 1977, $2, is available from the Tennessee Energy Authority, 226 Capitol Blvd., Bldg. Suite 707, Nashville, TN 37219.

2. Imagine that you are a public official with power to legislate energy use.

   a. How would you reach decisions? Would you listen to certain groups of citizens more than to others? Or would you postpone action indefinitely in hopes that need for legislation would disappear in time?
   b. Assume that you do legislate specific energy-related actions. How would you put them into effect?
   c. What factors could change the need for, or effectiveness of, changes by law?
   d. Would you ever approve and put into effect unpopular laws? Give reason and at least one example for your answer.

3. Imagine that you are the recreational planner for your community. Gasoline shortages are keeping your neighbors closer to home than usual and you are pressured to find more low-energy outlets for their leisure hours.

   a. Would you schedule athletic events only during daylight hours? What would be the advantages and disadvantages of this policy?
   b. What areas in your town are near major concentrations of people and could be used for parks?
   c. Would bicycle and jogging trails be popular in your area? If so, suggest a route for one.
   d. Some people would like to exercise during their lunch hour. What provisions for recreation can you make at or near major workplaces?
   e. Where are the most energy-efficient places in town to hold social gatherings, bazaars, fairs, tournament games, square dances, play practices, etc.?
   f. What recreational activities available in your community require the least use of non-renewable fuels? The least use of human energy? Would these factors dictate your decision on which ones to encourage with use of your limited time and money?

4. Assume that you are going to buy the family car.

   a. What type of car would you buy? Why?
   b. Would you buy a used auto? Why or why not?
   c. What options would be necessary on this car?
   d. Calculate what the life-cycle cost in dollars of the car of your choice is likely to be.
   e. Make a list of advantages and a list of costs of using an auto that are not usually measured in dollars.

5. Assume that you have responsibility for choosing a local citizen to receive a $1,000 conservation award and gold medal from the President of the U.S.

   a. What kind of lifestyle and behavior would you look for?
   b. Do you think the person you're seeking is most likely to be young, middle aged, or old? living on very limited income, having an average salary, or living comfortably on high income? knowing much or little about energy problems?
   c. What energy conserving features would you look for on the interior of candidates' living spaces?

   d. If the persons being considered own homes, what features would you hope to find on the exterior of their houses?
   e. If candidates own cars, what kinds and what uses would you expect?
   f. Design an appropriate medal that the President can use for this award.
   g. Would you put any limitations on how the $1,000 is spent, in the interest of saving energy?

6. Imagine that you are a creative director of an advertising agency. The local utility companies have hired you to develop an advertising campaign, using any media you choose, to encourage energy conservation in Iowa.

   a. Who would be some of your target audiences?
      Would you use different approaches for each?
   b. Enlist classmates to be your photographers, artists, creative writers, programmers, and salespeople. Decide whether to write songs or slogans for radio; to prepare graphics for newspapers and billboards; to prepare brief action skits for television; to design T-shirts and campaign buttons for mass distribution; to design bumper stickers or to assemble a photo essay for a magazine, etc. Then do it.
   c. Find out what community resources (information, publication space, manpower, materials) may be available to you for this project. Decide which ones you'll use, or which are most likely to give your advertising a wide audience.

7. If you were mayor of your city and you were starting a citizens' advisory committee to make suggestions for energy conservation . . .

   a. What kinds of persons (by education, occupation, political philosophy, age, experiences, wealth) would you choose? How many would you want? Explain.
   b. What problems would you assign this committee?
   c. What responsibilities and decision-making power would the committee have?
   d. Who would follow-through on committee recommendations?

8. Assuming that you want to live in the most uncomplicated and least energy-expensive way in the future:

   a. Where in the world would you live? Why? Where would you not live and why?
   b. How would you support yourself?
   c. In what ways would you use less energy than now?
   d. What kind of house would you buy or build?

9. You have just been hired as energy manager for a large school system. Imagine that you can earn a salary bonus by reducing the winter heat bills on the several buildings maintained by the board of education.

   a. How would you encourage students and teachers to save energy?
   b. What maintenance procedures would you require?
   c. What new devices or materials would you hope to install?

10. Assume you are on the planning commission and must approve or reject a permit for strip mining at the edge of town.

    a. What economic factors would you consider?
    b. What social factors should be weighed?
    c. What environmental factors would be critical in your area?
    d. What other kinds of information would you want before making your decision?

11. As superintendent of the local schools, you are asked to consider changing the school calendar. In order to reduce skyrocketing fuel costs, the Taxpayers' Union has recommended that the major vacation starting in mid-December be extended through January and February. Extra school days in June and August, when building heat is not required, would be substituted.

    a. Would you save much money under this scheme? How low can you leave thermostats if children are not present?
    b. What would the effects of this new schedule be on local businesses? on parents? on student learning?
    c. How would your decision affect busing and other forms of student transportation?
    d. What activities would students likely substitute for school during a long winter vacation?
    e. What other social and economic effects might your agreement with the Taxpayers' Union have?

12. Imagine that you live in a house you've owned for years, near people you know well and like. Now you've just been offered an attractive, interesting job, but its location is fifty miles away. "Move or commute?" is the decision you must make.

    a. What choice would be most economical in dollars; in time; in energy; in personal and social stress?
    b. Before you answer 12a., what kinds of information would you need? Whom would you consult?
    c. What events and costs are impossible to anticipate (if any)?
    d. If you do move, what energy-saving steps would you take while relocating?
    e. If you do not move, what energy conservation options do you have?

Teacher's Guide to Energy Use and Decision Making

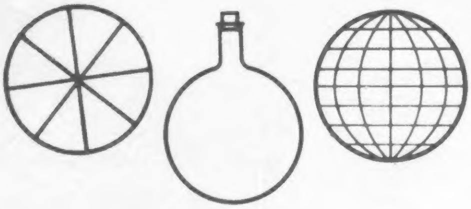
Some explanation may be due for situation 4d.

Life-cycle costing is an attempt to estimate expense of buying, maintaining, and retiring an article over the time of its useful life. Such calculations allow comparison of articles with similar initial costs, but differences in service life. For example, a wedding dress costing \$200, worn only once has a life-cycle cost of \$200 per day (plus any cleaning and storage costs, minus any resale value). A business suit costing \$200, worn 30 times a year for five years, will need regular dry cleaning . . . say \$100 worth over the five years. So the suit's life-cycle cost is $\frac{\$200 + \$100}{30 \times 5 \text{ wearings}}$ = \$2.00 per day.

Disposal cost, if any, should be added to the total cost. Or salvage value, if any, should be subtracted to reduce this figure.

Estimating the life-cycle cost of a car is done in a similar manner. cost of ownership is more than purchase price minus resale or salvage value. One must add insurance costs; license and registration fees; fuel required; maintenance and repair costs; interest expenses if a loan was required; washing, waxing, parking, and storage expenses. Then compute:

$$\frac{\text{Costs incurred + Costs anticipated during useful life}}{\text{Time of useful life}} = \text{Life-cycle cost}$$



An Historical Digest:

Energy Storage and Use

Every living thing is an energy converter and an energy storage tank as well. Usually small plants like bacteria and fungi decompose dead plants and animals. The results are water, carbon dioxide, and mineral residues that can be rather quickly reused by another season's growth.

In our midwestern climate, dead leaves spread over garden soil usually decompose completely in less than a year's time. The body of a bird buried in a paper box "disappears" in six months or less, depending on the season. Decomposers work faster in summer and in milder climates. However, sometimes plant and animal remains are buried by mud, mineral-rich water, ice, rockslides, volcanic activities, or other natural agents. The result may be to limit the amount of oxygen or other necessary resources for the process of decay.

Any covering also has weight, putting pressure on the organic materials. then the products of incomplete decomposition, trapped in a pocket or layer of earth's crust, may become compressed packages of concentrated energy called gas, petroleum, and coal.

The repackaging of plant energy into such concentrated form took hundreds of millions of years. Geologists think that most of the world's coal is the remains of land plants that thrived 300-500 million years ago. They assume that Earth was warmer and wetter and that the atmosphere had more carbon dioxide than it does now, conditions favoring luxuriant plant growth.

Oil is believed to be the remains of marine animals and plants that sunk to the bottom of great inland seas that covered Earth tens of millions of years ago. The pressure of accumulating sediments on the decaying plants and animals and the resulting heat of compression helped to cook an energy-rich soup. The broth was rich in many complex hydrocarbons (petroleum) plus the lighter simple hydrocarbon we call natural gas.

These energy resources or fossil fuels were produced and stored under Earth's surface long before any men appeared. The first peoples of Earth knew nothing of these buried treasures. They kept alive and warm by the food they gathered and hunted, and the coverings they made for their bodies. They learned to shelter themselves from seasonal winds by using caves. Eventually some persons among them learned to use and control fire which was started by lightning.

Fire provided extra warmth, protection from predators, and light that extended time for people. No longer did darkness bring only sleep. They gained extra hours for socializing, developing language, making pictures, fashioning better tools, keeping records. For the first time they could plan excursions into areas of the world that had greater seasonal changes, letting fire be their portable heater.

Ice Ages came and went, perhaps as many as twenty of them. The most recent one ebbed approximately 10,000 years ago. Man survived, with wood still his primary fire source. He became more efficient in collecting solar energy, however, as he became adept in growing and harvesting crops and in domesticating animals both for power and for meat.

Some people learned to use vegetable oil (olive oil in particular) for lamps, and others used candles of rendered animal fat (tallow). Whale oil was used more than 1,000 years ago. Beeswax was long popular for its clean burning compared to tallow. All of these, as well as wood, were renewable energy sources, those that could be regrown over periods of time that are short compared to the length of a man's life.

Then someone discovered coal. By the 13th century A.D. persons living near Newcastle, England were using it regularly. It was probably easier to dig up a few bucketsful there than to find and cut an equivalent amount of firewood to keep the home fires burning. Also, the supply of coal seemed endless.

Although some people were using coal as early as the 9th century, for the first thousand years of consumption the rate of use was very low. There were fewer people than now. Houses were smaller. Nearly all work was done in, or around, the home. There were no offices, large stores, and factories to heat. Churches and theaters had no heat nor water. People traveled on foot, on horseback, or in animal-powered carts. Their clothes were hand-crafted products of natural materials: linen, cotton, wool, silk, and fur.

The situation changed in the 19th century. Rapid industrialization, mechanical transportation systems, changing lifestyles, and rapid population growth all contributed to a persistent increase in the amount of energy consumed.

Petroleum became a significant part of the energy picture more than 100 years ago. The booming oil industry nearly doubled its production every eight years from 1870 to 1970. Much of this inherited mineral wealth was spent for production of energy-consuming technologies. Man has brought himself many comforts and services by harnessing machines and has enlarged his list of "necessities for the good life" in the process.

283

AN HISTORICAL DIGEST

Activity:

Modeling the time scale of energy storage and use.

Materials needed:

Energy Calendar
Wall or floor space
Meter sticks or rulers with metric scale
Masking tape
Pens or pencils
2 rolls of standard adding machine paper (per class)
or
2 spools of thread (500 yds.) plus toothpicks and paper

Procedure:

Tape a roll of adding machine paper around the classroom walls, or spread it on the floor, or use a corridor (whichever your teacher suggests). Assume that it is about 45 meters long. You are going to let this length of paper represent the whole 4 1/2 billion year history of Earth as outlined on your Energy Calendar. What will the scale of your model be?

If you use the entire tape and it is 45 m long, 45 : 4,500,000,000 as 1 : 100,000,000 or 1 m represents 100,000,000 years. This is the "upper limit" (unless you have additional tape and space to spread it out).

If you use the ratio of 1 m = 100 million years, how much time does 1 mm represent?

What other ratios could you use?

Mark the beginning of the paper tape as the beginning of Earth time or as Now, depending on which direction your group prefers to work (from past to present, or from present to past). Then enter the next event in the sequence at the appropriate distance from "start" of your tape. Continue to enter all the Energy Calendar dates, one at a time, at carefully measured intervals so that a fair relationship is kept.

If your group has difficulty getting the most recent events represented on your paper roll, you may want to "expand" only the more current events involving man's use of energy on another roll or sheet of paper. Choose another ratio of length to time that allows space for the entries you'd like to make.

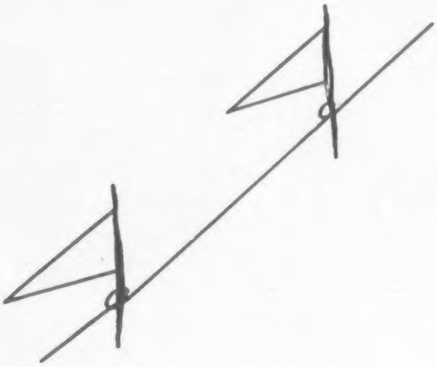
Note here—the time span I'd like to account for is ________________ years.

Then if 1 mm represents 1 yr., I'd need a paper __________________long.

Or, if 1 mm represents 10 yrs., I'd need a paper ________________ long.

Using the paper provided by your teacher, measure off the intervals on your "expanded" scale and identify each mark according to the event it represents.

If you are using thread instead of paper, secure one end with a thumbtack to a desk edge. Or have a fellow student hold it. Tie a toothpick into the thread at proper intervals for the events they represent. You can attach paper labels to the toothpicks to identify the calendar listings. Calculate the scale on the basis of having 450 m of thread.



Extended Activity:

You now have a graphic model of some energy-related events on Earth. But this is only one way to show how short a time man has intensively used concentrated fuels that were stored for millions of years. Here you have expressed one kind of measure, time, in terms of another, linear space. Can you think of a more timely model?

Compare the age of Earth to a single day. Then how long would the duration of man's use of fossil fuels be?

Or, what if the age of Earth were compared to your age? Then how long would man's energy binge (the last 110 years) be in that analogy?

AN ENERGY CALENDAR

Birthday of planet Earth was 4.5 billion years ago.

Oldest known rocks are 3.3 billion years old.
First plants (algae) appeared 3.2 billion years ago.

First known animals (jellyfish) died 1.2 billion years ago.
Fossils first became abundant 600 million years ago.

Age of fishes began 400 million years ago.
Fern-like plants grew densely, became basis of COAL, 300 million years ago.

First dinosaurs thrived 225 million years ago.
First mammals appeared 200 million years ago.

Decline of dinosaurs occurred about 135 million years ago. Along with fossil plants, some became fossil soup (PETROLEUM).
First primates trapped in a fossil record lived 70 million years ago.

Man-like creatures appeared about 3 million years ago.
Ice Ages began 1.7 million (1,700,000) years ago.

Man began to use fire, 500,000 B.C.
Last glaciers retreated, 8000 B.C.

Man learned to smelt metal and make bronze, 3000 B.C.
Iron technology was begun, 1000 B.C.

Waterwheels were used in Greece, 300 B.C.
Book by Vitruvius describes watermills, steam jets, and other machines, 27 B.C.

Mt. Vesuvius destroys Pompeii, 79 A.D.
Waterwheels come to Europe, 500 A.D.

First windmills were used 650 A.D.
Coal was burned in an English monastery, 852 A.D.

Whale oil came into use for lighting, 900 A.D.
Coal was regularly used for home heating in Newcastle, England, 1300 A.D.

Windmills started to drain the Netherlands, 1500 A.D.
Modern steam engine was conceived by Watt, 1765.

First oil well was drilled in Pennsylvania, 1857.
Otto designed the 4-stroke internal combustion engine, 1876.

First incandescent lighting was provided to a small area of New York City, 1882.
Becquerel discovered radioactivity, 1896.

Wright brothers flew the first successful airplane, 1903.
First jet plane flew, 1942.

First nuclear explosions were detonated in 1945.
First nuclear electric power plant in the U.S. was completed, 1958.

Man first walked on the moon in 1969.
"Energy Crisis" of limited supplies and higher fuel prices became a public concern in the winter of 1973-7

Now—?

Teacher's Guide to An Historical Digest

This activity requires one or two class periods, depending on how much preparatory discussion (if any) your class needs, and whether or not you follow up the model-making with discussion of models in general--reasons for keeping equal proportions, areas of similarity and differences, alternative media possibilities, etc. The optional extended activities would also probably require a second or third class period.

Materials to be procured in advance are 2-5 adding machine rolls (number depending on class size and whether or not the "expanded section" is done as a group or individually) OR two 500-750 yard rolls of thread and a box of flat toothpicks. Duplicate the "Energy Calendar" as well as the instruction sheets so that every student has a copy. Provide meter sticks or rulers with the metric scale.

Procedure assumes a cooperative class venture.

Note that there are a total of 36 events on the calendar. It is suggested that each student be assigned to measure off the place for at least one of them.

If the class is large, you may want to divide it into two working groups. Let one work on the "maxi-scale" of the first 14 or 15 dates. There will be great difficulty (impossibility!) in fitting in any recent dates (since man's first use of fire). So you may assign the second group to work on a separate tape representing the energy chronology starting with man's use of fire. The scale chosen should, of course, be different.

What should the ratio of length to time be? You may wish to let the class decide. Students are advised on the instruction sheet that the tape is about 45 m long, so with Earth's existence represented by the entire length of tape, the maximum scale available is 1 m to 100,000,000 years. Then 1 cm represents 1,000,000 years and 1 mm is 100,000 years.

To plot the smaller time segment of 500,000 years, the expanded scale can be 1 m = 10,000 years if a whole roll is used, or 1 m = 50,000 years if only 10 m are used.

You will need the perimeter of a large room for spreading out the roll. A corridor floor or a gym wall is ideal. Or you can double-back lengths of tape along a classroom wall or blackboard. Use masking tape to hold the paper to the wall or floor where students can measure out the appropriate lengths and also see the whole sweep at once.

Assign each student responsibility for marking location of at least one of the dates on the Energy Calendar onto the class's timeline. Have the class decide whether to start with Now or with "birthday of Earth" on one end of the tape and then mark in the other events at appropriate intervals.

Whether or not the "expanded model" of the shorter time period from now to 500,000 B.C. is subject for another whole roll of tape or for only about 10 m of one depends on the space available to you. Anything less than 10 m is impractical for group work (too much crowding and shoving at close quarters). Instead you may prefer to give short lengths, like 5 m (representing 500,000 years so 1 mm = 100 years) to each student for individual scaling and completion of a man/energy time-line.

Thread gives an interesting alternative because it allows greater length in less space. Again, assign each student an event on the Energy Calendar. Let one be anchor man, representing "birthday of Earth," holding one end of the thread. Or, if you have a convenient place to thumbtack one end, you may prefer to do that. Then have students measure out lengths in proportion to the time intervals--about 10 million years to each meter; 10,000 years to each mm. Loop the thread around a toothpick wherever each event should lie. Paper labels identifying the "milestones" can be attached to the toothpicks. Students can hold the thread at their "event-station" until the model is complete, doubling back the thread as many times as is necessary to keep it within the available workspace. However, even the more generous scale allowed by the length of thread is not grand enogh to allow marking of any events since the last glacial retreat. So again, an expanded scale on a second spool is recommended. A scale of 1,000 or 2,000 years per meter is generous; 10,000 years per meter is adequate.

Extended Activities:

Have each student prepare a report on one of the events recorded on the Energy Calendar.

Discuss the relative importance of the events listed. Which was most important for mankind? for other living organisms? for the planet Earth? Make a list of the criteria suggested for selecting various priorities. Where does the class come nearest to consensus--on particular events (which may be chosen for different reasons) or on the criteria for selecting the most important ones (though the choices vary)?

Have the class (or selected representatives from it) show and explain its models to another class in your school.

Trends and Consequences:

The Futures Wheel

Background:

The energy transition is making us aware that energy is a potent social and economic force. Some of the effects of shortages of fuel, such as inflation and unemployment, hint of lifestyles in the future that may be different from those to which we are accustomed. We want to know not only about the choices available to us, but also what the consequences of various alternatives may mean to us, to our society, and to the world community in the future.

Activity:

A futures wheel is a tool to help students examine possibilities and consequences of following trends or using innovations. It is a graphic way to emphasize complex interrelationships.

Materials:

Magic markers and newsprint or butcher paper; or
large chalkboard and chalk

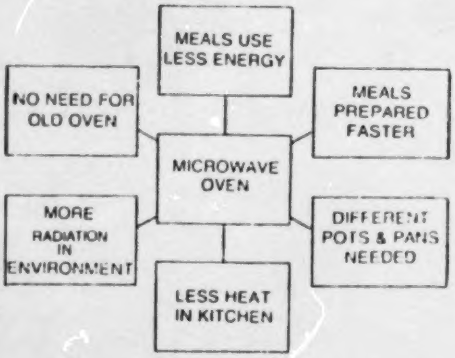
Directions:

Near the center of the paper or the chalkboard, write the name of an energy innovation or trend (a gasoline tax increase of $.50/gallon; farmers refuse construction of high voltage lines over their property; sales of wood burning stoves are up 500%; solar heating systems are mass-produced; thermostats in all schools are kept at 65°; only Australia has uranium left; fusion succeeds; electric cars are widely used; sun rights of individual property owners are protected by law; etc.).

Draw a circle or a box around the item chosen. Then ask the class, "What are the probable consequences of this innovation or trend?"

Write each of the effects outside and around the circled energy innovation or trend and draw circles or boxes around each of them. Draw lines connecting them to the original. An example for "microwave oven" is shown. The initial reactions are called first order consequences. They are indicated by the single lines connecting the energy innovation with its possible consequences.

Diagrams from Joel Barker,
Director, Future Studies Dept.
Science Museum of Minnesota,
St. Paul, Minnesota 55101
Used with permission.



Now ask the question--"What are the possible effects of this consequence?" for each of the first order consequences. Draw in and connect each secondary effect proposed by students with two lines between it and the first order to which it relates. Continue this process for about four orders of consequences, using three lines for connecting third order ones and four lines for the fourth order.

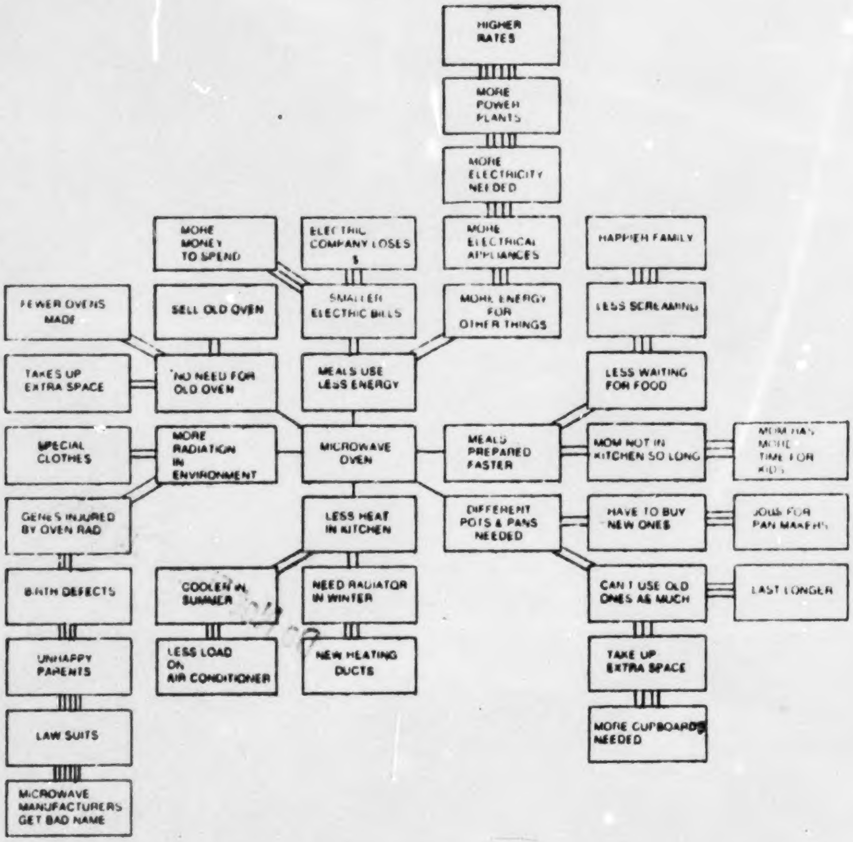
It's usually wise to limit the futures wheel to no more than four orders in classroom use. Not only do possibilities get more remote, but also there are visual, spatial, and conceptual limits to be respected. (However, some students may be intrigued enough to enjoy the challenge of a futures wheel assignment to be done outside of class with a less limited time constraint.)

A futures wheel developed for the microwave oven is included for an example of a way to show multiple consequences. The number of connecting lines between boxes indicates the order of each effect.

Remember that the assumptions learners make are not right or wrong and do not have to be highly probable. They represent possibilities only and should be recognized as such.

Now that you have shown students how to draw a futures wheel, ask each to make one individually or with a small group (4 to 6 are recommended for brainstorming), using a different energy-related innovation or energy trend. On completion, hang the wheels on the walls and have students share them with the class.

As a follow-up activity, have students categorize the nature of the various consequences. Are they social, economic, technological, environmental, or related to world politics for example. (First let students suggest all the categories they can recognize. Then combine or elaborate on them as necessary.) Then tally the responses by category. What kinds of effects were easiest (most often mentioned) to foresee?


HIGHER RATES
MORE POWER PLANTS
MORE ELECTRICITY NEEDED
MORE ELECTRICAL APPLIANCES
MORE ENERGY FOR OTHER THINGS
MORE MONEY TO SPEND
ELECTRIC COMPANY LOSES $
SMALLER ELECTRIC BILLS
HAPPIER FAMILY
LESS SCREAMING
LESS WAITING FOR FOOD
FEWER OVENS MADE
SELL OLD OVEN
TAKES UP EXTRA SPACE
NO NEED FOR OLD OVEN
MEALS USE LESS ENERGY
SPECIAL CLOTHES
MORE RADIATION IN ENVIRONMENT
MICROWAVE OVEN
MEALS PREPARED FASTER
MOM NOT IN KITCHEN SO LONG
MOM HAS MORE TIME FOR KIDS
GENES INJURED BY OVEN RAD
LESS HEAT IN KITCHEN
DIFFERENT POTS & PANS NEEDED
HAVE TO BUY NEW ONES
JOBS FOR PAN MAKERS
BIRTH DEFECTS
COOLER IN SUMMER
NEED RADIATOR IN WINTER
CAN'T USE OLD ONES AS MUCH
LAST LONGER
UNHAPPY PARENTS
LESS LOAD ON AIR CONDITIONER
NEW HEATING DUCTS
TAKE UP EXTRA SPACE
LAW SUITS
MORE CUPBOARDS NEEDED
MICROWAVE MANUFACTURERS GET BAD NAME

Reference: J. A. Barker, "Futures Study in Curriculum Planning," pp. 56-61 in The Role of Future Studies in Public Education. Misc. Publ. of the Science Museum of Minnesota, No. 4. St. Paul, MN, 55101.

PAGE 468 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

Ye Olde Times

FIRE IS BASIC,
GREEK ASSERTS

1

Ephesus, Asia Minor, c. 500 B.C.

Ideas of the reclusive philosopher Heraclitus are exciting the educated citizens of Ephesus. Fire made the universe, not the gods, Heraclitus claims. "Everything originates and ends in a fire that kindles itself and goes on refueling itself until it puts itself out. And matter is like fire in that it always moves, always changes somewhat," states this student of nature.

King Darius of Persia has tried to honor Heraclitus for his provocative thinking, but the Greek sage tactlessly refuses all honors and society as well. He was recently seen gathering roots and berries outside of town, and friends report that he spends months at a time alone in the countryside. Heraclitus's refusal to cultivate admirers and followers and to lead a more civilized life may retard the spread of his natural science. Ephesians marvel, nevertheless, that this cold man has such hot ideas.

"If sunbeams were weapons of
war we would have had solar
energy centuries ago."
--Sir George Porter

SECRET WEAPON
BURNS INVADERS

2

Syracuse, Sicily c. 214 B.C.

Under the direction of the respected mathematician and inventor, Archimedes, the citizens of Syracuse succeeded in turning back a fleet of Roman war galleys. Wooden missiles and masses of stone were hurled at the invaders with such force that they had little opportunity to use their own war engines against the city's walls before being terrified by an unnatural fire.

Archimedes' mechanical devices for defending his birthplace are well known for their ingenuity and usefulness in both long- and short-range combat. Today, though, he demonstrated an awesome new power to set fire to distant sailing ships without using projectiles.

One of the few surviving eyewitnesses of the Roman rout claims that he saw a blinding light appear on the steep Sicilian hillside a half-mile ahead of him just one second before the sails on a neighboring galley burst into flame. Though this Roman soldier was standing on deck with the sun behind him, he then saw another brilliant flash come from the same area of the Greek stronghold. Before he could regain his vision, he smelled the charred remains of burnt cloth and felt the heat of flames licking the masts of his own ship. How he escaped, he declines to say, for fear of being sent back for cremation by that wizard of Syracuse, Archimedes.

Citizens within the besieged city report that Archimedes borrowed every available mirror that wealth and vanity made common in this prosperous town. Then he stationed dozens of stalwart men on a steep hillside facing the harbor. Each held and moved a metallic mirror as Archimedes directed, focusing reflected sunlight on the sail of a Roman galley. The Syracuseans were surprised and delighted that this novel strategy set fire to a couple of the advancing ships. The effect seemed to demoralize the other Roman crews, and the enemy retreated back to the mainland.

This battle will be long remembered, whatever the outcome of the ongoing Punic Wars.

ACADEMY HONORS YOUTH FOR LIGHTING RESEARCH

3

Paris, France, 1766.

Although he did not win the coveted 2,000 livres offered for an essay on means of lighting city streets, young Antoine Lavoisier has earned a unique honor. A special gold medal struck "by order of the King" was presented to him by the President of the Academy of Science.

The unprecedented distinction was given to the 23-year-old author for his exposition of the theoretical aspects of the lighting problem. Lavoisier had studied every kind of lamp available. He considered candle-powered lights as well as oil burners and calculated relative efficiencies of different fuels, of variously styled wicks, of elliptical and hyperbolic reflectors, and of assorted light standards. The economics of the project for street illumination were also explored mathematically. The versatile fellow estimated costs of installation and maintenance and made suggestions for financing the civic improvement.

Seldom have intellectual energies been so masterfully displayed over a problem of public concern. Fellow citizens are pleased that Lavoisier's merit was officially recognized.

FLAMELESS METHOD MELTS STEEL BARS

4

Paris, France, 1772.

Using only sunlight, Antoine Lavoisier melted steel today in his outdoor funace. The renowned French chemist has built an original contraption on a flat, wheeled platform that can be pushed to track the sun horizontally. The critical components mounted on the platform include a large parabolic mirror and two huge lenses made hollow, like flattened wine bottles. These lenses were borrowed from the Academy of Sciences and were modified slightly by Monsieur Lavoisier. He filled each lens cavity with his favorite beverage, spirits well known for their capacity to warm the consumer.

Supporting rods for the lens-holder can be handcranked to raise and lower the lens system vertically. The parabolic mirror bounces and concentrates the lens-gathered light into one point where the steel sample (or other material) can be strategically placed.

Today's demonstration was not so dramatic as was Lavoisier's previous use of sunshine to shrink the size of a diamond. However, the potential usefulness of a solar device to blacksmiths, jewelers, glassblowers, brick makers, and other craftsman became apparent today. This puts the new arrangement of burning lenses in a more practical light and may justify its further development.

Lavoisier has already announced plans to experiment further, perhaps using wines of varying color and clarity--or even less popular fluids--in subsequent models. Thus a range of "heat peaks" may be made available for specific jobs. Now if the distinguished chemist can find a reliably cloudless site for his sunlight concentrators, he may provide a focal point for some bright new industries.

DYNAMO INVENTION GENERATES ENERGY

5

London, October 28, 1831.

A laboratory assistant at the Royal Institution, Michael Faraday has invented a "dynamo" for converting mechanical force into electrical energy.

While continuing experiments begun by Monsieur Ampere, Mr. Faraday discovered that moving a magnet through a coil of copper wire caused a current to flow through the wire. This "electromagnetic induction" is the basis of his new dynamo which may lead to generation of low-cost electricity. It is also believed that it may be the basis for a whole new generation of machines to make men's lives easier.

Though Mr. Faraday's invention is as yet only a novelty, insiders at the Palace predict that it will earn him honors but not a penny in royalties. One skeptical politician already has asked the experimenter what use his little electrical toy may have. Faraday replied, "Some day you will be able to tax it."

FIRST POWER STATION SERVES NEW YORK

6

New York, New York, March 12, 1882.

The first establishment for electrical energy supply was opened as the "Pearl Street Edison Station" in New York City. Coming only three years after T. A. Edison's invention of a sootless incandescent lamp, this power station will supply enough electricity to light up a small group of adjacent buildings.

Experts on electrical transmission anticipate the possibility of networks of power stations and long-distance transmission of electricity in the decades ahead. However, much more research and development of high-voltage systems will be necessary before these goals become realizable.

COAL TAR MAKES BASE FOR GERMAN INDUSTRY

7

Germany, 1890.

The booming new chemical industry has made Germany the world leader in manufacture of dyes and pigments, fertilizers, insecticides, medicines, and synthetic drugs. All of these products are derived from coal tar, the raw material for an ever-increasing variety of products and chemicals that meet ready acceptance in world markets.

Much of Germany's current prosperity is based on the work of one man, August von Hofmann. His research into the organic components of coal gas and coal tar led to discovery of several compounds--anilines being the most notable--that are the feeder stocks for a whole series of commercially valuable chemicals.

In former years Herr von Hofmann worked in London, England, as director of the Royal College of Chemistry. After the loss of both his patron (Prince Albert) and financial support for the college, von Hofmann returned to his fatherland. England's loss was our gain. Von Hofmann's unprecedented contributions to coal tar chemistry and its applications in practical life have brought international recognition to himself and to Germany.

PEDAL POWER CRAZE GROWS

8

New York, New York 1898.

Pneumatic tires have now made bicycling a comfortable as well as a practical means of transportation, and it is fast becoming America's favorite pastime. The geared-up transmission of the "safety" bicycle is also a factor in the new found popularity of this vehicle.

The older generation may remember previous models of bicycles that only the daring could endure. The "ordinary" bicycle manufactured since 1872 had a front wheel nearly ten times as large as the rear one and favored the tallest riders. A "geared ordinary" was an improvement on the basic model but still required a skillful rider to maneuver it.

The first crank-driven bicycle was initially manufactured even earlier, in 1865. Called a velocipede, its wooden wheels were nearly equal in size, covered with thick iron tires, and attached to a cast iron frame. If its excessive weight didn't discourage the rider, then its terrifying vibration would. Also called "boneshaker," the velocipede never attained widespread popularity. It was, however, a more efficient device than its prototypes, the first bicycles. These were walk-along scooters one could really "ride" only downhill.

Now after 88 years of progressively better designs, bicycles are taking their place in city transportation plans. Bicycle racks are being installed at commuter train stations, shopping areas, and parks for the convenience of those who prefer freewheeling to walking.

PAGE 474 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

The Sun Press

A STIRRING SOURCE OF FARM HOT WATER

10

N. Y. State, March 1978.

Researchers at Cornell University, New York, are using a wind turbine to agitate water in a 30 gallon drum. As James Joule and Count Rumford both declared more than 100 years ago, heat is a product of motion. The system testing this premise keeps water agitated continuously in an insulated, air tight container at the base of a horizontal axis turbine. In 30 hours at a wind speed of 10 mph, the water temperature rises from 50° to 150° F. During the winter when wind speed sometimes doubles, production increases by a factor of 8, enough to heat 240 gallons of water.

The Cornell research team hopes to demonstrate that wind power can ease agricultural energy consumption. Dairy farms in particular use much hot water to clean milk handling equipment. However, the wind system design will easily adapt to domestic hot water and space heating uses, its developers claim. Professor W. W. Gunkel predicts that turbine manufacturers will be able to market a complete hot water package within 2 to 4 years. Hopefully it will be economical in windy areas.

A notable advantage of the Cornell system is that the water brakes the speed of the turbines in high winds, eliminating the need for complicated braking devices. Producing heat by direct agitation of the water also bypasses the need for any expensive conversion units to transfer wind speed into electrical energy.

SELF-LIQUIDATING WATER HEATERS

11

Lakeland, Florida, 1978.

Loans on installation of solar water heaters are being encouraged by the Florida Savings and Loan office in Lakeland. Consumer repayments are set at $25 a month regardless of the total amount loaned. This monthly installment approximates the expected utility bill reduction. Therefore, borrowers' budgets aren't likely to be affected by the loans.

299

VOICES ON THE WIND

12

Plymouth, N.H., January 1979.

Up in breezy New Hampshire, students at Plymouth State College have harnessed the wind to run the campus radio station.

The roof of the science building supports a windmill erected last year to demonstrate its possibility as a generator of electricity. At first the windmill lit up a sign declaring "Wind Power." but now the windmill is used to power the college's 10-watt radio station.

On an average day, ordinary wind runs the station for 3 to 4 hours. Stronger winds in the 24 mph range produce all the power needed for a broadcast day. The campus radio staff uses a jingle to advertise times when "This hour is 100% wind-propelled."

JAPAN LIGHTS UP ON NUCLEAR POWER

13

Tokyo, Japan, January 1979

Ten percent of this island nation's electricity is provided by nuclear power plants with a peak capacity of 9.6 million kilowatts. Among the world's nations, only the U.S. has more nuclear power capacity.

Japan is constructing more nuclear generating facilities, aiming to provide nearly 22% of her electrical needs within the next 10 years. Otherwise she is totally dependent on imported fossil fuels, especially oil.

A FUELISH REVERSAL

14

Newcastle, England, 1977.

"Carrying coals to Newcastle" has long described the futile effort of taking some commodity to an area that already has a surplus of it. Newcastle started selling off its coal in the 13th century, and that fuel became its major export from the 17th century to the present.

The end of an era came this year when coal industry officials admitted that reserves are so low that Newcastle cannot meet her own present needs for coal, much less export any. Hopefully North Sea oil will come into the pipelines soon enough to keep this industrial center going.

Meanwhile, "carrying coals to Newcastle" would seem to be a highly appropriate response to her needs.

PENNSYLVANIA LEADS IN WEATHERPROOFING

15

Harrisburg, PA, December 1978

If there was a national contest for energy-wise home improvement, the state of Pennsylvania would probably win it. The Department of Community Affairs has already helped insulate and winter-proof over 35,000 homes. It is continuing this program at a rate of 1,500 houses a month.

Over 800 people were trained in skills ranging from basic construction to energy auditing. This job corps has been a basic ingredient in the success of the energy-saving project.

State officials estimate that the first 24,000 households weatherproofed had saved the equivalent of 114,285 barrels of oil by January 1978. This was a cost reduction of $2.4 million or $100 per household for the first year.

MODEST TREASURES CONVERT TO ENERGY

16

Here and There, 1979.

Calorific Recovery Anaerobic Process, Inc. (Oklahoma) uses leftover cattle feed and other wastes to produce methane gas. Bacterial action decomposes the material in large tanks or "digesters."

Sugar cane wastes are burned to generate electrical power in Hawaii, yielding about 40% of the island's electricity.

Train carloads of coffee grounds, a byproduct of instant coffee production, are now mixed with conventional fuels to fire the boilers at an American food-processing company's coffee plant.

Garbage is used as a partial substitute for oil in the power-generating plants of a half-dozen European cities.

A FAMILIAR RING?

17

"There is one obstacle to further advance . . . . The increasing price of fuels necessary to work machinery. Coal and oil are going up and are strictly limited in quantity . . . We are spendthrifts in the matter of fuel and are using our capital for our running expenses.

"In relation to coal and oil, the world's annual consumption has become so enormous that we are now actually within measurable distance of the end of the supply. What shall we do when we have no more coal or oil?

"Alcohol makes a beautifully clean and efficient fuel . . . we can make alcohol from sawdust, the waste product of our mills . . . from cornstalks and in fact from almost any vegetable matter capable of fermentation. Our growing crops and even weeds can be used. The waste products of our farms are available for this purpose, and even the garbage from our cities."

--Alexander Graham Bell, before the District of Columbia's McKinley Manual Training School graduation, February 1, 1917.

OIL DOES GROW ON TREES (SOMETIMES)

18

Manila, Philippine Islands and Berkeley, CA, 1979.

Can oil grow on trees--or even shrubs? The answer is yes.

Filipino scientists have shown that coconut oil can substitute for diesel fuel. It burns cleanly and causes less engine corrosion than conventional fuel. According to the Philippine Coconut Authority, no engine modifications were necessry.

Commercial production of coco diesel is not planned at this time, however, because it is more expensive than imported fuel.

Another renewable source of liquid fuel may be the "gopher plant" that lives in the California desert. Its milky sap is rich in hydrocarbon similar to those in gasoline.

University of California biochemist Melvin Calvin estimates that an acre of gopher plants may produce 10 to 50 barrels of oil each year. Dr. Calvin calculates that an area the size of the state of Arizona could supply enough hydrocarbons to meet current U.S. needs for gasoline.

Plants would be cut off at ground level and run through a crushing machine to extract the sap. Sap would then be processed in an ordinary oil refinery. Meanwhile, new shoots would sprout from the cut stumps to produce a whole new field of oil-bearing shrubs.

Believing in the power of gopher plants, Dr. Calvin has already begun raising them on his ranch in northern California. He has become the West's first gasoline bush farmer.

BICYCLE COMMUTING: A WHEEL DEAL

19

U.S., 1979.

While many commuters are simply piling more people into their cars, others have taken to their bicycles. Though heavy traffic, poor road conditions, and lack of secure parking facilities have discouraged many would-be bicycle commuters, programs across the country are providing model solutions to these problems.

For those in the Washington, DC area who are perhaps reluctant to try bicycle commuting, the Washington Area Bicyclist Association is making it easier. Their innovative Pedal Pool Program provides escorts for first-time bicycle commuters and is collecting routes from seasoned commuters to publish in a Washington area bicycle user's map. The program also includes efforts to eliminate trouble spots identified by commuters, from potholes to poor traffic patterns which make bicycle travel dangerous.

In San Diego and Seattle, cyclists can ease their commutes by going part of the way by bus, now that some city buses are equipped with bicycle racks. San Diego's program has been operating since 1976 and racks on 16 buses on three routes assist 13,000 cyclists a year. One popular route runs between the beaches, where parking is at a premium, to the sprawling university campus, where a bicycle is almost a necessity for getting around. Route schedules are not affected by cyclists racking their bikes--it only takes about 10 seconds to lock a bike in place.

California's State Transportation Authority has set up a shuttle bus and trailer system to shuttle cyclists across the San Francisco-Oakland bridge for a small fee. The Bay Area Rapid Transit System also permits bicycles on its trains during off-peak hours at no extra charge.

As a solution to one major commuter cycling problem, finding a secure place to park a bicycle, subway stations in Washington, DC now have bicycle lockers which they rent for $25 for three months to cyclists who want to split their commute between pedal power and public transportation.

Bicyclists themselves have been working to make their contributions to energy conservation more readily available. Local bicycle clubs have worked to develop bike paths, and greater safety on commuting routes. Members also encourage employers to provide safe parking and changing facilities. A national organization that works to improve road conditions and other concerns of cyclists provides information on ways and means to do so.*

League of American Wheelmen, 19 S. Bothwell, Palatine, IL 60067. (312) 991-1200.

Star Gazette

"All the future that's fit to print"

FROM HUMAN FOOD TO MACHINE FUEL

20

Brasilia, Brazil, 1995.

The energy of sugar cane and tapioca (manioc) has long been a staple in the diet of Brazilian citizens. But these plants now fuel machinery as well.

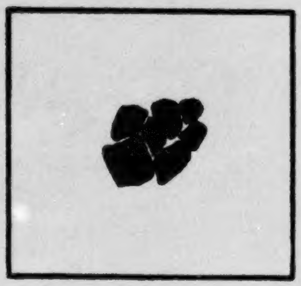
Fermentation of sugar produces alcohol that is being concentrated to 95% purity by alcohol-distilling plants. The resultant ethanol provides locally-produced fuel for industrial combustion engines. This large-scale, government assisted production of alcohol has greatly reduced Brazilian oil imports.

Success of the farm-grown energy program was forecast as early as 1978 when 500 telephone-repair service cars were operated on 190-proof grain alcohol distilled from sugar cane. The superior performance of this fleet of Volkswagens plus the lack of polluting emissions from these cars appealed to most citizens. Many car owners converted their car engines to use this clean-burning ethyl alcohol. This popular response spurred automakers to market a modified interal combustion engine and to meet the demand for cars and farm machiery that burn renewable, home grown fuel.

WILL COAL BECOME
NEXT POWER BASE?

Cambridge, England, 4000 A.D.

Dr. O. R. Frisch, noted scientist and writer, has been considering the feasibility of coal as a source of electrical power generation ever since this mineral was discovered in several archeologicge digs on the Western Atlantic Continental Mass. His report to our readers follows:



COAL:
possibilities
and
problems

THE FRISCH REPORT

The recent discovery of coal (black, fossilized plant remains) in a number of places offers an interesting alternative to the production of power from fission. Some of the places where coal has been found show indeed signs of previous exploitation by prehistoric men, who, however, probably used it for jewels and to blacken their faces at religious ceremonies.

The power potentials depend on the fact that coal can be readily oxidized, with the production of a high temperature and an energy of about 0.0000001 megawatt days per gram. That is, of course, very little, but large amounts of coal (perhaps millions of tons) appear to be available.

The chief advantage is that the critical amount is very much smaller for coal than for any fissile material. Fission plants become, as is well known, uneconomical below 50 megawatts, and a coal driven plant may be competitive for small communities (such as small islands) with small power requirements.

DESIGN OF A COAL REACTOR

The main problem is to achieve free, yet controlled, access of oxygen to the fuel elements. The kinetics of the coal-oxygen reaction are much more complicated than fission kinetics, and not yet completely understood. A differential equation which approximates the behavior of the reaction has been set up, but its solution is possible only in the simplest cases.

It is therefore proposed to make the reaction vessel in the form of a cylinder, with perforated walls to allow the combustion gases to escape. A concentric inner cylinder, also perforated, serves to introduce the oxygen while the fuel elements are placed between the two cylinders. The necessary presence of end plates poses a difficult but not insoluble mathematical problem.

FUEL ELEMENTS

It is likely that these will be easier to manufacture than in the case of fission reactors. Canning is unnecessary and indeed undesirable since it would make it impossible for the oxygen to gain access to the fuel. Various lattices have been calculated and it appears that the simplest of all--a close packing of equal spheres--is likely to be satisfactory. Computations are in progress to determine the optimum size of the spheres and the required tolerances. Coal is soft and easy to machine, so the manufacture of the spheres should present no major problem.

OXYDANT

Pure oxygen is, of course, ideal but costly; it is therefore proposed to use air in the first place. However, it must be remembered that air contains 78% nitrogen. If even a fraction of that combined with the carbon of the coal to form the highly toxic gas cyanogen, this would constitute a grave health hazard (see below).

OPERATION AND CONTROL

To start the reaction, one requires a fairly high temperature of about 988°C. This is most conveniently achieved by passing an electrical current between the inner and outer cylinder (the end plates being made of insulating ceramic). A current of several thousand amperes is needed, at some 30 volts, and the required large storage battery will add substatially to the cost of the installation.

There is the possibility of starting the reaction by some auxiliary self-starting reaction, such as that between phosphine and hydrogen peroxide; that is being looked into. Once the reaction is started, its rate can be controlled by adjusting the rate at which oxygen is admitted. This is almost as simple as the use of control rods in a conventional fission reactor.

CORROSION

The walls of the reactor must withstand a temperature of well over 1,000°C in the presence of oxygen, nitrogen, carbon monoxide and dioxide as well as small amounts of sulphur dioxide and other impurities, some still unknown. Few metals and ceramics can withstand such gruelling conditions. Niobium with a thin lining of nickel might be an attractive possibility, but probably solid nickel will have to be used. For the ceramic, fused thoria appears to be the best bet.

HEALTH HAZARDS

The main health hazard is attached to the gaseous waste products. They contain not only carbon monoxide and sulphur dioxide (both highly toxic) but also a number of carcinogenic compounds such as phenanthrene and others. To discharge these into the air is impossible; it would cause the tolerance level to be exceeded for several miles around the reactor.

It is therefore necessary to collect the gaseous waste in suitable containers, pending chemical detoxification. Alternatively, the waste might be mixed with hydrogen and filled into large balloons which are subsequently released.

The solid waste products will have to be removed at frequent intervals (perhaps as often as daily), but the health hazards involved in that operation can easily be minimized by the use of conventional remote-handling equipment. The waste could then be taken out to sea and dumped.

There is a possibility--though it may seem remote--that the oxygen supply may get out of control. This would lead to melting of the entire reactor and the liberation of vast amounts of toxic gases. Here is a grave argument against the use of coal in favor of fission reactors which have proved their complete safety over a period of several thousand years. It will probably take decades before a control system of sufficient reliability can be evolved to allay the fears of those to whom the safety of our people is entrusted.

PAGES 485-486 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

Teacher's Guide to **Ye Olde Times,** The Sun Press and **Star Gazette**

Note the past, present, and future orientation of the various stories. Some suggest the nucleus of a "history of science" in popular form. Others are comments on contemporary responses to energy transitions and problems. Still others project a future when energy management is assumed to be different from that of the 1980's.

You may use these articles in a number of ways. Some suggestions are:

Discussion starters.

Supplementary reading.

Examples of reports students may write for their class, school newspaper or a special energy newsletter.

Focus for critical examination. Some questions to ask are:

1. What is the value-orientation of the person or nation mentioned in the article?
2. What is the point of view of the writer of the article?
3. How did or how will the person, idea, or technology described affect mankind?
4. How do you rate the importance of the person, idea, or technology described in this article? Explain.

Introduction to the history of science. Have students write either journalistic interviews, reports, or case studies on other energy-minded scientists and inventors. Some suggestions are:

Marie Curie
James Dewar
Nikola Tesla
Georg Ohm
Peter Mitchell (1978 Nobel Prize)
James Fourier
Michael Faraday
Alfred Kastler (1966 Nobel Prize)
Heinrich Hertz
Thomas Edison
Joseph Henry
Leon Foucault
Alessandro Volta
Benjamin Thomson (Count Rumford)
James Watt
Humphry Davy
James P. Joule
Lise Meitner
Albert Einstein

#2 SECRET WEAPON BURNS INVADERS

Whether or not Archimedes did set fire to ships' sails with sunlight has been subject for a controversy in the "letters" column of Science News (summer issues, 1978). One of the letters supporting the feasibility of this story appeared on July 15, 1978:

> ". . . I once saw a demonstration where 30 plane mirrors reflecting sunlight to the same area of a wood plank easily set it on fire. If the sun's image is spread over one-half degree (about .009 radians) then a one-square-meter mirror would spread its reflected energy over $9^2 = 81$ square meters at a distance of one kilometer. If the defenders of Syracuse had a battery of 30 x 81 = 2,430 such mirrors on their walls, aimed with the signal mirror method, they could have equaled the wood plank demonstration.

Even if Archimedes could have come up with only 600 mirrors and a burning distance of half a kilometer, he should have been able to convince the Romans to keep their distance. Surely there could have been 600 families of Syracuse that could afford a large polished mirror. When it was not in use defending the city, it would make a fine addition to the hallway."

Robert W. Davis
Gainesville, FL

#20 FROM HUMAN FOOD TO MACHINE FUEL

Brasilia, Brazil, 1995

The following suggestions for discussion questions (appropriate in various social science classes) were contributed by Sr. Margaret Brockamp of Kuemper High School, Carroll, Iowa.

Objective:

An examination of how this policy of alcohol production from sugar cane and tapioca affects a country like Brazil where extreme poverty exists.

Note the Paradox:

Brazil is one of the largest and potentially richest countries in the world, yet a great amount of deprivation and poverty exists. In recent years Brazil has experienced significant growth and development of its human and physical resources.

What percent of Brazilians rely on sugar cane and tapioca as their staple diet?

How could their diet be changed? Would it be difficult to do so?

Discuss some of the community problems which would be raised for the building of alcohol-distilling plants in a less developed country such as Brazil.

Specify the conditions which would need to be present to extend these plants.

Research the extent to which Brazil has developed ethanol and whether or not this knowledge has spread to other Latin American countries.

If widespread use of ethanol were developed, what would be the results for developing societies and for the world in general?

#21 WILL COAL BECOME NEXT POWER BASE

This imaginative article, forecasting a possible response to re-discovery of coal, parallels the nuclear debate in many respects. Unlike most science fiction, it postulates no new technolgoy but a reinvention of an older one. This is perhaps analogous to the situation with solar use of heat, especially in bermed or underground buildings, and in greenhouses.

Dr. Frisch has been intimately involved with nuclear physics and the development of its potential and problems. He obtained his Ph.D. at the University of Vienna in 1926. He taught in Berlin and Hamburg, and later worked in Bohr's laboratory in Copenhagen. When his aunt, Lise Meitner, fled Germany and evolved the suggestion that uranium was undergoing fission under neutron bombardment, he collaborated in the paper that resulted. Dr. Frisch has since earned a reputation as a popular science writer. Along with his permission to reprint this imaginative and humorous article, Professor Frisch wrote, "I hope Iowans are so proud of their coal that they remember it is a valuable chemical, too valuable for burning!"

Some suggested questions for student discussion or reports:

1. What date would you assign to this article? Why? (It was arbitrarily chosen by this author, not by Dr. Frisch.)

2. How many generations away is 4,000 A.D.? (Good place to discuss length between generations and subsequent "doubling" time . . . . It varies with age of the woman at time of childbearing. See charts attached to GROWING TIME. A practical "mean" of 25 years is often suggested, but so is the statistic that more than half of all U.S. women complete their families before age 26.)

3. Could people really "forget" all about coal in as little as 2,000 years? Explain your answer. If "no," why not? If "yes," what conditions do you foresee that would lead to abandonment of this resource?

4. What time-frame did Dr. Frisch himself consider in writing this report? (Clue is in last paragraph.)

5. In giving permission for this article to be reprinted, Dr. Frisch wrote, "I hope Iowans are so proud of their coal that they remember it is a valuable chemical, too valuable for burning!" What does he mean?

    a. What is a "chemical"?
    b. What are the uses of coal?
    c. Which of these uses is most important to you? to your school? to your future job or your parents' jobs?
    d. Which uses of coal could you live without?

6. What are the similarities in the considerations Dr. Frisch reports regarding use of coal and those which have slowed the growth of the nuclear power industry? What are the differences in the trade-offs these two fuel sources require?

7. What other power sources that we now use are likely to be forgotten by 4,000 A.D.?

8. Make a guess of your own on either what the "new" or the "established" power sources may be at some future time. Choose your time frame.
    a. What are its disadvantages/advantages?
    b. What does it cost?
    c. How does it affect peoples' lives?

    Describe in some detail the power source itself. Description may be in essay form, a poem, drama, a picture, a collage, a model, a demonstration, or any other media the teacher is willing to accept.

9. An alternative activity: Suter's "Utility" (included in this activity) is also an example of futuristic thinking as an art form. Some students may want to use it as an "end point" and discuss or write a sequence of events that led to this "break-through." Others may wish to comment on social and legal impacts of this kind of power system at the future time described by Suter. Still others may wish to consider "What's next?" after the time portrayed by Suter. What subsequent refinements in energy production would likely follow the scenario Suter imagines?